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# An Analysis of Weapon System Acquisition Intervals, Past and Present

G. K. Smith, E. T. Friedmann

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A Report prepared for the

OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING and THE UNITED STATES AIR FORCE

Rand
SANTA MONICA, CA. 90406

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Critics of weapon system acquisition frequently claim that management process changes during the 1960s and 1970s caused the acquisition cycle to lengthen. A review of three classes of aerospace systems--aircraft, missiles and helicopters--shows that over the past 30 years the time from the beginning of full scale development to delivery of the first operational item has changed only slightly, but average production rates have fallen by half. The planning phase corresponding to today's Phase I (from Milestone I to Milestone II) has nearly doubled, and the introduction of Phase Zero may have added still more time, but evidence on Phase Zero effects is still tenuous. Opportunities for shortening the acquisition cycle time appear to lie mainly in flexible application of the regulations governing approval of the Mission Element Need Statement, and in some cases the Services should be allowed to proceed simultaneously with Phase Zero, and even Phase I, studies while the MENS is being reviewed. 142 pp.

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# PREFACE

Defense executives, contractors, and Congressional review agencies have long been concerned with the assumption that the weapons acquisition cycle required an inordinately long time to complete. Such concern was heightened with the appearance in 1976 of Office of Management and Budget (OMB) Circular A-109, which emphasized early and formal approval of mission element need. Since then, many study groups have examined various aspects of the acquisition cycle and have offered suggestions on how to accelerate the planning, development, testing, or production phases. With few exceptions, however, those studies proceeded from the unverified assumption that most phases of the acquisition cycle have been lengthening, and they have devoted attention to ideas for shortening it.

Under sponsorship of the Office of the Under Secretary of Defense for Research and Engineering (OUSDRE), The Rand Corporation in 1979 completed a survey of weapon system acquisition experience during the 1970s. That study included a brief review of acquisition intervals—the extent to which discrete phases of acquisition have been growing longer—limited to military aircraft. The evidence suggested that for the phases of acquisition occurring after the beginning of full-scale development, the only noticeable change was a decline in production rates proportional to the growth in unit cost. However, the limited scope of that study precluded any significant analysis of the acquisition phases that precede full-scale development. At the request of OUSDRE, Rand undertook a follow-on study examining the early phases of acquisition and possible ways to shorten the cycle. The results are presented in this report.

This study drew heavily on earlier unpublished research conducted by Rand for the U.S. Air Force under Project AIR FORCE (Contract F49620-77-C-0023). For the sake of completeness, both the earlier work and the present analysis are reported here under joint sponsorship.

This report should be of interest to Air Force and OSD officials involved in establishing acquisition policy and to researchers who need some knowledge of acquisition intervals for past systems. The appendixes contain an extensive compilation of basic data that may be useful in future studies.

## SUMMARY

During the past two decades, several layers of management and several formal review milestones have been added to the organization and procedures for managing weapon system acquisition. Critics of the process frequently assume that these changes have caused the overall acquisition cycle to lengthen and that the delays have undesirably lessened the timeliness and value of the final product. This report addresses three questions, two analytical and one prescriptive: (1) Has the overall acquisition cycle really lengthened significantly during the past few decades, and if so what phases of the cycle have been most affected? (2) Do changes in the length of the acquisition cycle, or any phase of it, derive directly from previous changes in OSD organization or procedures? and (3) Regardless of past trends or events, are there practical ways to reduce the length of the present acquisition cycle without undesirably altering program outcomes?

For the historical review, three classes of aerospace systems were examined: aircraft, missiles (excluding long-range surface-to-surface ballistic missiles), and helicopters. These are the only kinds of systems that have been developed in significant numbers more or less continuously over several postwar decades and that have been subject to the full panoply of decision review and ratification processes. Because of sparseness of data on the early milestones of many systems, the principal effort was devoted to aircraft systems.

To evaluate historical trends in acquisition intervals, an attempt was made to determine six major milestone dates for each historical system:

1. Issuance of a formal, Service-level requirement for the system.
2. Start of demonstration and validation analysis (equivalent to today's Milestone I);
3. Start of full-scale engineering development (equivalent to today's Milestone II);
4. First flight (or equivalent test) of the initial development model;
5. Delivery to the user of the first fully operational system (the first production item after the development lot); and
6. Delivery of the 200th operational unit.

The central phase of the acquisition cycle has remained fairly unchanged and the early and late phases have been lengthening. The time from beginning of full-scale development to first flight has remained remarkably constant over a period of three decades, and the additional time required to deliver the first operational item has changed only slightly. The largest change during the hardware development and production phase has been a steady reduction in average production rate, which has fallen by half over the period. This drop in production rate appears to be closely linked to the increase in average unit price; any change in this trend can occur only through a reduction in unit cost or an increase in investment rate.

The greatest change appears to have been before the beginning of full-scale hardware development. The phase corresponding to today's Phase I (from Milestone I to Milestone II) has nearly doubled over the past 30 years. That seems to

be a long-term trend, and there is no direct evidence that the management changes introduced during the past ten years caused any significant increase in the trend. In fact, the largest changes were apparently at the beginning of the 1960s.

The addition of a Phase Zero is the only change in management organization and procedures that can be even tenuously linked to an increase in acquisition intervals. During the 1950s and 1960s the preparation and approval of a formal requirement for the system were largely concurrent with Phase I, whereas today's policy calls for that process to be completed (ending in an approved Mission Element Needs Statement) and Phase Zero studies conducted before Phase I starts. The rather short span of experience with the MENS and Phase Zero studies precludes any firm conclusions about their effect on decision time. If the decision process is administered according to the letter of the directives, with each phase being completed before the next starts, then it seems likely that the introduction of the MENS, together with Phase Zero studies, may add another year or two to the historical trend. In that case, the total decision time preceding the start of full-scale development will have increased by a factor of two to three since the early 1950s. However, the actual administration of the decision process is likely to be somewhat flexible, and more experience must be obtained before we draw any firm conclusions regarding the effects of the MENS and Phase Zero.

Increases in the duration of the demonstration and validation phase (at least, increases of the size noted herein) should not automatically be deemed undesirable. Projects undertaken in the 1960s exhibited relatively larger cost growth, schedule slip, and performance shortfalls than similar programs of the 1970s, and in comparable ways the 1960s were "better" than the 1950s. Some of the time growth identified in this analysis appears to be linked to observed improvements in the ability of defense managers to produce systems that come closer to predicted cost, schedule, and performance than was the case in earlier years. Furthermore, delays in the initial decision phase will not necessarily translate into the delivery of a "less modern" system. Many elements of technology are continually changing, and designs are updated and refined throughout the initial decision phase, so the quality of the delivered product may well be improving as time goes by. An extended initial decision phase will ordinarily cause a slippage in initial operational capability dates, but if a delay occurs the system may be able to take advantage of new knowledge and could well be a more effective weapon when fielded.

There are several possible approaches to shortening the pre-Milestone II decision time. If the letter of the current directives is to be strictly observed, with MENS approval required before Phase Zero, then opportunities lie mainly in the area of streamlining budget procedures. Gaps of a year or more could occur because the necessary study funds were not budgeted before MENS approval, thus requiring another budget cycle before funds can be made available. To cope with this problem it may be appropriate to establish a "revolving fund." Once a MENS is approved, work could promptly start on the ensuing studies using money from the fund, and then later when the regular project appropriations have been provided by Congress, the "advanced" money could be repaid to the fund. Such a procedure would probably require the establishment of a specific budget line item for the revolving fund. Otherwise, the process would require no change in policy or procedure and could save over a year in some cases.

A more functional approach to reducing front-end decision time would be to

administer the process with more flexibility than is suggested by the regulations and directives. As long as it is OSD policy to use the MENS as a screening mechanism for all projects, with the intent of approving a MENS only for those projects that have high assurance of being carried through the full acquisition cycle, the review process will be lengthy. However, there is a wide variation among projects in terms of perceived urgency of operational need and in the degree of consensus that exists regarding the major issues surrounding the project. Under some conditions it would seem appropriate to permit the Services to proceed with Phase Zero studies on the basis of a draft MENS, and require final MENS approval only as a necessary condition for a DSARC I (or in some cases even DSARC II) review.

This suggestion does not imply a reversion to the days when programs were started with inadequate attention to long range consequences and were difficult to cancel after they accumulated momentum and broad political support. Although a small step back from the present formal policy, such a measure seems necessary if decision times are to be significantly reduced. Furthermore, the approach suggested here leaves intact many opportunities for control that did not exist during the 1950s and 1960s, and it in no way contravenes the letter or the spirit of OMB circular A-109. By having the Service submit a draft MENS before starting Phase Zero studies, the OSD would insure itself of being fully informed and would still have an early opportunity to review both the need for the system and the recommended approach to satisfying that need. Surely it should not be too difficult to cancel, or significantly redirect, a program at that stage.

Such a procedure would almost certainly reduce the front-end decision time (compared with the time required under strict observance of the directives), but it would also entail some additional costs of one kind or another, and may encounter substantial and valid objections from Service, OSD, or OMB authorities. However, without some actions along the general lines suggested here, there seems to be no way to significantly reduce the duration of Phase Zero or Phase I without abandoning essential and useful elements of the systems acquisition review process.

# GLOSSARY

| | |
|---|---|
| ADO | Advanced Development Objective. |
| AFSC | Air Force Systems Command. |
| CFP | Concept Formulation Paper. |
| DCP | Development Concept Paper. |
| DepSecDef | Deputy Secretary of Defense. |
| DSARC | Defense System Acquisition Review Council. |
| DT&E | Development Test and Evaluation. |
| FSD | Full-scale Development. |
| GOR | General Operational Requirement. |
| IOC | Date of Initial Operational Capability. |
| IOT&E | Initial Operational Test and Evaluation. |
| LOH | Light Observation Helicopter. |
| LTV | Ling-Temco-Vought Corporation. |
| L/C | Letter Contract. |
| MENS | Mission Element Need Statement. |
| Milestone Zero | Approval of MENS and authorization of concept exploration phase. |
| Milestone I | Program review by DSARC to authorize start of demonstration and validation phase. |
| Milestone II | Program review by DSARC to authorize start of full scale development. |
| Milestone III | Program review by DSARC to authorize start of rate production. |
| OMB | Office of Management and Budget. |
| OSD | Office of the Secretary of Defense. |
| Phase Zero | Interval between MENS approval and Milestone I. |
| Phase I | Interval between Milestone I and Milestone II. |
| RFP | Request for Proposal. |
| RFQ | Request for Quotation. |
| SOR | Specific Operational Requirement. |
| TAC | USAF Tactical Air Command. |
| TADS/PNVS | Tactical Air Data System/Pilots Night Vision System. |

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# I. INTRODUCTION

Critics of the defense systems acquisition process frequently complain that it takes far too long to develop a new system and get it to the users. They further argue that such delays have serious consequences, leading to the delivery of outdated equipment and to excessive development costs. Finally, some critics argue that systems can be acquired in significantly less time than is common today, citing examples from earlier years (most often the 1950s) as models of how programs should be conducted.

A central element of this theme is that the management practices and organizations that have evolved during the 1960s and 1970s have introduced unnecessary bureaucratic delays in the acquisition process. In particular, the Defense Systems Acquisition Review Council (DSARC), established in 1969, and OMB Circular A-109, issued in 1976, are often cited as sources of delay, through both the additional layers of management they created and the tendency to prolong the decision process by demanding milestone reviews before the project goes on to a subsequent phase. The strong implication of this theme is that things used to be better before the introduction of these organizations and procedures, and that there is now "slack time" in the system that could be eliminated without incurring unacceptable (or even significant) penalties.

Several studies have addressed this topic during the past few years. The Defense Science Board made it a major theme of their 1977 summer study.[1] Other works worth noting include an Air University thesis,[2] a study by the Logistics Management Institute,[3] and a Concept Issue Paper published by Hq. United States Air Force.[4] However, with the exception of the Hq. USAF paper, little quantitative evidence has been presented to support the claims of increased acquisition cycle times.

The present study was undertaken with three broad objectives. The first was to review the history of military acquisition programs over the past three decades to determine if acquisition intervals have indeed been growing longer and, if they have, to determine in what part of the acquisition cycle the lengthening has been most pronounced. The second was to see if any such lengthening of intervals could be directly associated with any particular management process or policy. Finally, regardless of the historical trends, we wished to identify any opportunities for significantly shortening the cycle.

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[1] *Report of the Acquisition Cycle Task Force*, Defense Science Board 1977 Summer Study, Final report, 15 March 1978.

[2] Maj. David T. Spencer, *Alternatives for Shortening the Systems Acquisition Cycle: Milestone 0 to DSARC II*, Air Command and Staff College thesis, May 1979.

[3] William G. Moeller et al., *Accelerating the Decision Process in Major System Acquisition*, Logistics Management Institute, September 1979.

[4] Lt. Col. Jon S. Eckert, *Trends in U.S. Air Force Tactical Fighter Life Cycles*, Concept Issue Paper 80-3, Hq. USAF, April 1980.

## THE EVOLUTION OF ACQUISITION POLICY

It is useful to first examine the basic phases of an acquisition cycle and to review the evolution of major policy approaches to management of that cycle. The acquisition cycle is generally thought to consist of three major phases:

1. *The Planning Phase:* Before a new system is committed to full-scale hardware development, there is usually a several-year period of analysis and exploratory development. During that period a mission need is established (the "requirement"), and sometimes a number of alternative solutions (systems) are considered. Critical technical issues are explored through component development programs. As more is learned about the probable cost and performance of the alternatives, attention focuses on the preferred solution, and that design concept is defined in increasing detail. Finally, the merits of the favored system are weighed against the latest evaluation of the threat and, if the system is sufficiently attractive, a commitment is made to develop the system.[5]
2. *The Development Phase:* The full-scale hardware is developed, an initial batch of units is fabricated and tested, and production tooling is installed.
3. *The Production Phase:* Units are produced for delivery to the operating forces.

In practice the distinction between adjacent phases is frequently blurred in various ways, and sometimes there are distinct sub-phases in one or more of the major elements. In fact, it is the management of the transition from one phase to the next that has been a major emphasis of acquisition policy. As we examine how that policy has changed, we find that there have been three broadly different policy sets, roughly corresponding to the 1950s, the 1960s, and the 1970s.

Before the 1960s there was no formal DoD acquisition policy, largely because the Secretary of Defense did not have the authority to enforce such a policy. When the Department of Defense was established in 1947 it was a loose confederation of the three military departments, and the Secretary of Defense could, at most, give some general direction to these departments.[6] The first Secretary of Defense, James Forrestal, lost no time in recommending that "the statutory authority of the Secretary of Defense should be materially strengthened . . . by making it clear that the Secretary of Defense has the responsibility for exercising direction, authority, and control over the departments of the National Military Establishment."[7] However, that power was only slowly granted, and throughout the 1950s the individual services generally ran their own acquisition programs with very little interference by OSD. Although several changes were made in the structure of DoD in the intervening years, it was not until 1958 that the Secretary of Defense was given the authority to direct and control the military departments rather than merely to supervise them. The Secretary of Defense became operating head of DoD;

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[5]This sequence of reviews and decisions can be compressed into a few months or extended over a decade or more, depending on the perceived urgency of need and the availability of design concepts to satisfy that need adequately and practically.

[6]Charles J. Hitch, "Evolution of the Department of Defense," in Richard Head and Eavin J. Rokke (eds.), *American Defense Policy*, Johns Hopkins Press, Baltimore, 3d ed., p. 347.

[7]*First Report of the Secretary of Defense*, 1948, Washington, D.C., 1948, p. 3.

and although the military departments were still separately organized, they were no longer autonomous.

### The McNamara Policies

This authority was not fully exercised until Robert McNamara became Secretary of Defense in 1961. He believed in active management from the top and chose to take a role in all aspects of programs, rather than waiting for problems and conflicts to be brought to his attention.[8] Many of his reforms, such as the Planning, Programming and Budgeting System (PPBS) and the emphasis on cost effectiveness, acted as means of centralizing power and decisionmaking within the Office of the Secretary of Defense (OSD).

Early in 1964, with the publication of DoD Directive 3200.9, DoD adopted the Air Force procedure of dividing the acquisition cycle into three phases, although not the three outlined above. Instead, there were two planning phases (the Concept Formulation Phase and the Contract Definition Phase), followed by the Acquisition Phase, which included development and production. During the Concept Formulation Phase a decision was made about whether a system was needed. That decision was based primarily on paper cost-effectiveness studies, which estimated the costs and capabilities of the system and were to demonstrate that the required technology was available. During the Contract Definition Phase two or more contractors produced formal proposals for conducting the Acquisition Phase (equivalent to today's Full-Scale Development and Production Phases). Those proposals included design specifications and firm cost and schedule figures. That was also primarily a paper exercise, although contractors usually did some work with hardware in the process of preparing the proposals. Following further studies and analyses, the proposals were the basis for selecting a contractor for development and production.[9] The intent of the policy was that the firm cost estimates made in the proposals were to be used as the basis for fixed-price contracts, which were thought to provide a better incentive for cost reduction and require less direct government supervision of contractors than the cost reimbursement contracts that had been common previously. (In a cost reimbursement contract, the amount a contractor receives for his work depends in some way on his costs; in a fixed-price contract, the government and the contractor agree on a set price before the contract award.)[10] In some cases, the design, manufacture, testing, and post-production support were contracted for under a single fixed-price contract, a practice known as Total Package Procurement (TPP). This was thought to allow the government greater cost control during all phases with a minimum of government examination of the contractor's cost data. It was also expected to allow greater concurrency of

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[8]Alain Enthoven and K. Wayne Smith, *How Much Is Enough?* Harper & Row, New York, 1971, p. 32.

[9]Lt. Col. William F. Brockman, USAF, *Acquisition Strategy for the 1970s*, Air War College, Maxwell Air Force Base, Alabama, 1972, p. 21.

[10]Because fixed-price contracts can have escalation clauses or provisions for price renegotiation if the original cost estimates are considerably off target, the distinction between fixed-price and cost reimbursements contracts is not a clear one. For more on the various types of contracts used from 1947 to 1977, see Barry R. Lenk, *Government Procurement Policy: A Survey of Strategies and Techniques*, George Washington University Program in Logistics, Washington, D.C., 1977.

development and production, leading to shorter acquisition times and consequent cost savings.

## The Packard Policies

Melvin Laird became Secretary of Defense in January 1969, but it was David Packard, his Deputy Secretary of Defense, who took charge of acquisition policy. By that time it had become clear that many of Secretary McNamara's policies had not been entirely successful. An OSD review of seven major weapon systems in May 1969 found that, on average, costs were 79 percent higher and development time was 32 percent longer than original estimates.[11]

In the years 1969-1971 Deputy Secretary Packard issued a series of memoranda that made sweeping changes in acquisition policy. Then in 1971 he issued DoD Directive 5000.1, *Acquisition of Major Defense Systems*, which consolidated almost all of the major changes into a single document.

## Decision Milestones and DSARC

Deputy Secretary Packard felt that OSD, under Secretary McNamara, had tried to manage the details of each program too closely, without being systematic enough to give OSD adequate control over the programs. He wanted to decentralize management of the day-to-day decisions, but at the same time keep OSD informed of the progress of the programs and in control of them. To achieve this, he chose three points during major programs at which he required approval of the Secretary or Deputy Secretary of Defense before the program could continue:

- Milestone I: The beginning of concept demonstration and validation.
- Milestone II: The beginning of full-scale development.
- Milestone III: The beginning of high-rate production.

These decision points enabled the SECDEF to decide whether to begin development of a program, whether to accept a contractor's proposal and go into full-scale development, and whether to go into production. In addition, cost, performance. and schedule thresholds were to be established for each system. If any of these thresholds were breached, SECDEF review of the program was again required. Except for these reviews, management of the program was to be left to the services.

To help the SECDEF make these decisions, Deputy Secretary Packard created the Defense Systems Acquisition Review Council (DSARC), an advisory group of high-level OSD officials. Its task is to investigate a variety of issues regarding the system in question, and to advise the SECDEF of their findings and recommendations at each of the three milestones noted above. The product of each review is a recommendation, which becomes the SECDEF's primary source of information for milestone decisions. The milestones and DSARC reviews are designed to allow the SECDEF to maintain control of the acquisition process and to keep informed about the systems, while allowing the services to manage their programs without interference between reviews, assuming there are no breaches of program thresholds.

[11]House of Representatives Committee on Government Operations, *Hearing on Policy Changes in Weapon System Procurement*, September 22-24, 29, and 30, 1970, 91st Cong., 2d Sess., Washington, D.C., 1970, p. 11.

## Hardware Tests and Prototyping

During the McNamara years, risk reduction and contractor selection for full-scale development had been based mainly on paper studies. Deputy Secretary Packard believed that these studies had not provided adequate information so he ordered the increased use of hardware testing and prototyping and a corresponding reduction in dependence on paper studies. He also ordered that development-production concurrency was to be kept to a minimum. During the McNamara years, production commitments were often made and production begun before very much testing had been completed. In a number of cases, design problems were discovered only after a substantial amount of production work had been completed. This required expensive retrofits to try to resolve the design problem. Those efforts were not always successful, resulting in increased costs, disappointing performance, and production delays. To reduce the extent of such problems, Deputy Secretary Packard directed that no production work, except for the procurement of certain long lead time components, was to begin until testing had demonstrated the soundness of the design.

## Policy Initiatives After Packard

Although Deputy Secretary Packard left OSD in late 1971, the policies he introduced make up the bulk of present OSD acquisition policy. Since then only two substantial changes have been made in OSD policy. In 1973 a directive was issued ordering that each service have an agency, separate and distinct from the developing and using commands, responsible for Operations Testing and Evaluation (OT&E). That change was recommended by the Commission on Government Procurement, which stated that an independent agency would be more effective and objective than the user in conducting OT&E.[12] The directive also emphasized the importance of completing sufficient development and operational testing to provide a valid estimate of operational effectiveness and capability prior to contracting for production.

On April 5, 1976, the newly established Office of Federal Procurement Policy issued Circular A-109, which set a standard policy for all federal acquisition. On January 18, 1977, OSD issued a revised version of DoD Directive 5000.1 to bring DoD acquisition policy into compliance with Circular A-109. The important changes in acquisition policy caused by those directives were in the early part of the acquisition cycle. Before that time the conceptual phase was initiated at the discretion of the individual service and the work was typically performed by advanced planning groups without a formal System Program Office or Program Manager. Normally such work was devoted to a single system with clearly defined operational characteristics. After a substantial investment of time and money, the SECDEF would be asked by the service for a decision on the system at Milestone I. At that point the only real options open to the SECDEF were to approve that particular system or to reject the project. Not only did this allow substantial amounts of money to be spent on a system before OSD reviewed it, but it built up a constituency for the

[12] *Report of the Commission on Government Procurement*, Vol. 2, Washington, D.C., 1972, pp. 164-166.

development of the system, making it difficult to explore the possibility that other systems might perform the same mission better or at lower cost.

Under the A-109 policy revisions, the acquisition cycle begins with a service determination that there is a need for a system to perform a mission. The service then prepares a Mission Element Needs Statement (MENS), which expresses the need in terms of operational requirements rather than performance specifications or characteristics of the system. Since a particular type of system to meet the need is not specified, the exploration of a wider variety of alternative systems should be possible. To give OSD control over this portion of the acquisition cycle, a new Milestone Zero was added. When a service felt it had a mission need, a MENS had to be submitted for SECDEF approval before the exploration of systems could begin. Upon approval of the MENS, a System Program Office was to be established and a Program Manager appointed and given a charter.

It is clear from this brief review that there has been an increase in high level management and review of acquisition programs. The basic question addressed in this report is, Have those changes in policy and management practices had any significant effect on the time required for a system to pass through the entire acquisition cycle?

## DATA BASE

To determine with useful precision the existence of historical trends in acquisition cycle duration, it is necessary to examine classes of systems that have been developed in significant numbers more or less continuously over a period of several decades and that have been subject to the full panoply of management processes for decision review and ratification. Few adequate data samples are available. In this study attention was focused on aircraft, with some additional work being done on missiles (excluding long-range surface-to-surface ballistic missiles) and helicopters. Members of the three data sets are listed in Table 1. The period covers three decades, from the late 1940s to the late 1970s.

Data deficiencies made it impossible to include all systems in each class; coverage was dictated by the availability of data. Army and Navy systems are less well represented than Air Force systems, reflecting the existence at Rand of a better data base for Air Force systems.

A listing of the milestones for each system, together with source references and occasional comments on data problems, is contained in Appendix A (aircraft), Appendix B (helicopters), and Appendix C (missiles). A full bibliography of sources is included with each appendix. When several sources agree on a date, all such sources are cited (although we recognize that they all may have copied from the same original source, which may have been wrong). Discrepancies and contradictions are noted in footnotes.

## SELECTION OF MILESTONES

The next step was to identify consistent milestones or events in each program, determine the interval between those events, and track the intervals across time

Table 1

**DATA SAMPLE**

| Aircraft | | Helicopters | Missiles | |
|---|---|---|---|---|
| Fighters | Bombers | AH-1 | TM-61 | Matador |
| | | AH-64 | SM-64 | Navaho |
| F3D | B-47 | SH-3 | GAR-1 | Falcon |
| F-84 | B-52 | CH-3 | IM-99A | Bomarc |
| F-86 | B-58 | CH-46 | GAM-72 | Quail |
| F-89 | B-70 | CH-47 | TM-76B | Mace |
| F-94 | B-1 | CH-53 | GAM-77 | Hound Dog |
| F4D | | CH-54 | GAM-87 | Skybolt |
| F-100 | | UH-43 | AGM-69 | SRAM |
| F-101 | Attack | HH-52 | AGM-65 | Maverick |
| F-102 | | OH-6 | | Harpoon |
| F-104 | A3D | OH-23 | | ALCM/SLCM |
| F-105 | A-4 | OH-58 | | Pershing II |
| F-106 | A-5 | SH-34 | | |
| F4H/F-4 | A-6 | TH-55 | | |
| F-111 | A-7 | UH-1 | | |
| F-14 | A-10 | UH-2 | | |
| F-15 | | UH-60 | | |
| F-16 | | | | |
| F-18 | Transport | | | |
| Patrol | C-130 | | | |
| | C-133 | | | |
| S-3A | C-135 | | | |
| P-3 | C-141 | | | |
| | C-5 | | | |

so as to reveal any trends. Furthermore, it was clearly desirable to track milestones that correspond to events defined by today's management practices. Unfortunately, the changes in management practice have in turn changed the definition of some milestones, making tracking difficult. We succeeded in tracking six major milestones, as shown in Fig. 1.

1. Issuance of a formal, Service-level requirement for the system.
2. Beginning of Concept Demonstration and Validation (the equivalent of Milestone I today).
3. Beginning of full-scale development (equivalent to Milestone II today).
4. First flight (or equivalent full-scale system test).
5. Initial delivery of the first production unit to the operational forces.
6. Delivery of the 200th operational unit.

To simplify the quantitative analysis and to provide some continuity from one analysis step to the next, we used the six milestones to define five intervals, each beginning or ending with the start of full-scale development (see Fig. 1). A sixth interval was defined as the production phase (first to 200th operational unit delivered).

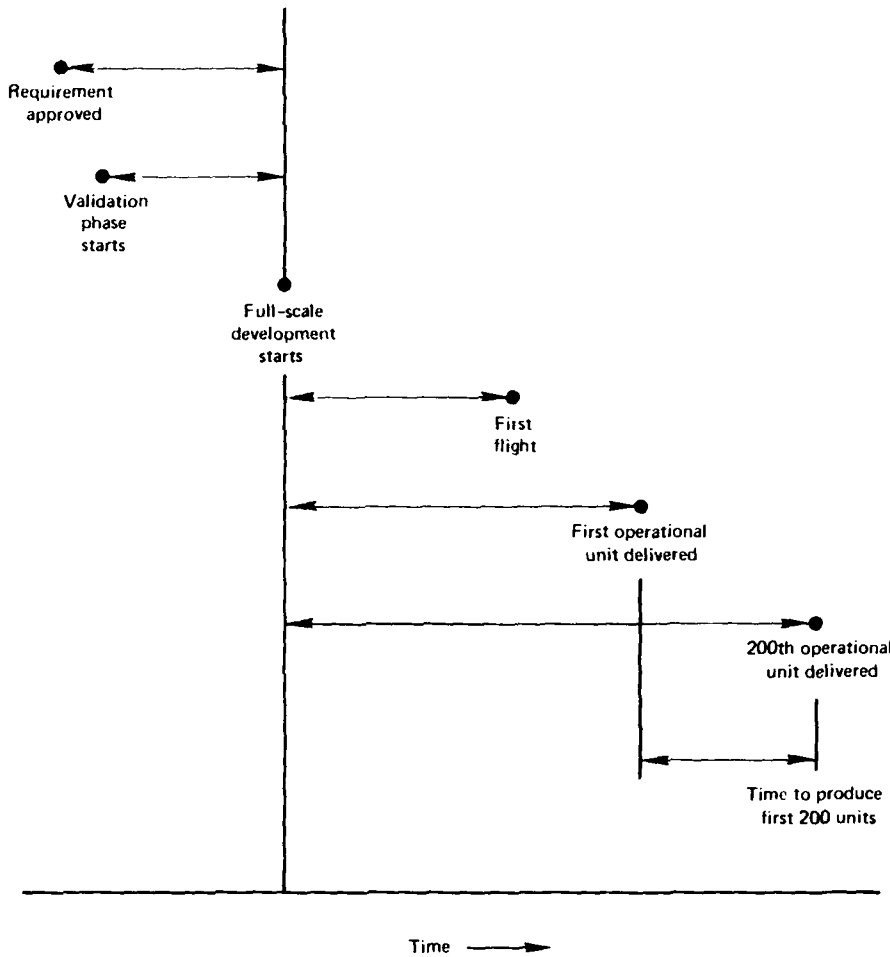


Fig. 1—Milestones tracked and intervals analyzed

The text of this report is devoted to an analysis of each of the six intervals. Section II discusses the planning phase activities, while the full-scale hardware development and production phases are discussed in Section III. Some observations on the overall results of the analysis and suggestions for shortening some elements of the acquisition cycle are discussed in Section IV.

Reviews of historical records of past programs usually can easily identify key dates and events that occurred in the second phase, but the first phase is much less well documented. The documentation requirements of current OSD management practices are overcoming that flaw, but earlier programs were simply not obliged to document key decisions or milestones during the analysis process leading up to the beginning of full-scale development. Hence there is an unfortunate disparity in quality and extent between data displayed in Sections II and III.

# II. THE PLANNING PHASE

It is usually not possible to identify the true beginnings of projects clearly because new systems tend to evolve from diffuse activities and interests that gradually accumulate support and focus. The phase of acquisition that starts from those fuzzy beginnings and extends to the beginning of full-scale development has been labeled and organized many ways in the past; we refer to it as the Planning Phase. The objective of this analysis is to determine if there has been any significant change in the length of time required for the pre-development planning tasks. If a significant change has occurred, we will want to know the source of that change and what might be done to reduce the overall time required to reach a firm go-ahead decision.

For each system, we attempted to reconstruct the major events and decisions that occurred before the beginning of full-scale development, but little information was available on program histories during that phase of acquisition. Milestones are few and documentation is sparse. Much of the analysis and decision process occurs within the DoD, and even within a particular Service, and there is little stimulus to record the steps involved in any systematic way. Nevertheless, some distinct milestones must be identified if we are to measure intervals. The two milestones selected for analysis in the present study are described below.

## REQUIREMENT FORMULATION

Only one event during the planning phase could be unambiguously identified in the various programs, the issuance of a formal requirement for the system. The date of issuance for the initial Service level formal requirement is shown in Table 2, together with the date at which full-scale development started. The interval between issuance of a formal requirement and the beginning of full-scale development is shown in Fig. 2 as a function of the FSD start date.[13] Before OMB Circular A-109 and the subsequent initiation of the Mission Element Need Statement (MENS) process in the DoD, the process of issuing a formal requirement for a new weapon system was conducted most unevenly. In some cases a system was truly initiated by the drafting of a requirement document, and the subsequent analysis and development can be traced to that stimulus. But in many other cases the formal requirement was prepared almost as an afterthought (sometimes after full-scale development had started) and was clearly issued as a meaningless formality.

Occasionally, no formal, headquarters-level requirement was ever issued; that happened most often with major systems that entered development following the emergence of a consensus at the highest levels of administration. In those instances, formal documentation became a trivial matter. Consequently, we have no historical data that can be directly compared with Phase Zero of today's acquisition cycle and

[13]The date of full-scale development start will be used as the independent variable in many of the trend charts to simplify comparison between one chart and another.

Table 2

PLANNING PHASE INTERVALS

| System | Equivalent Milestone I Date | Requirement Issue Date | FSD Start Date | Milestone I to FSD Start (months) | Requirement Date to FSD Start (months) |
|---|---|---|---|---|---|
| Aircraft | | | | | |
| F-84 | 10/44 | 9/44 | 1/45 | 3 | 4 |
| F-86 | 5/45 | 4/45 | 12/46 | 19 | 20 |
| B-47 | 10/43 | 11/44 | 9/48 | 59 | 46 |
| F-89 | 8/45 | 11/45 | 10/48 | 38 | 35 |
| F-94 | | 10/48 | 10/48 | | 0 |
| B-52 | 4/45 | 11/45 | 2/51 | 70 | 62 |
| F-102 | 1/49 | 8/50 | 9/51 | 32 | 13 |
| F-101 | 1/51 | 2/51 | 10/51 | 9 | 8 |
| F-100 | 9/50 | 1/51 | 2/52 | 17 | 13 |
| F-105 | 5/52 | 9/52 | 9/52 | 4 | 0 |
| C-130 | 1/51 | 3/51 | 9/52 | 20 | 18 |
| B-58 | 3/49 | 12/51 | 2/53 | 47 | 15 |
| F-104 | 1/53 | 12/52 | 7/54 | 18 | 19 |
| F-4 | 10/54 | | 5/55 | 7 | |
| A-6 | 5/57 | | 12/57 | 7 | |
| B-70 | 11/55 | 10/54 | 12/57 | 25 | 38 |
| C-141 | | 5/60 | 4/61 | | 11 |
| F-111 | 2/60 | 7/60 | 12/62 | 34 | 29 |
| A-7 | 12/62 | | 3/64 | 15 | |
| C-5 | 5/64 | 3/64 | 10/65 | 17 | 19 |
| F-14 | 11/67 | | 2/69 | 15 | |
| S-3 | 11/65 | 12/65 | 8/69 | 45 | 44 |
| F-15 | 4/65 | 6/68 | 12/69 | 56 | 18 |
| B-1 | 4/64 | 4/65 | 6/70 | 74 | 62 |
| A-10 | 12/69[a] | 12/66 | 1/73 | 37 | 73 |
| F-16 | 9/71 | 2/76 | 1/75 | 40 | -13 |
| F-18 | 9/71 | | 1/76 | 52 | |
| AV-8B | 3/76[a] | | 7/79 | 40 | |

Table 2—continued

| System | Equivalent Milestone I Date | Requirement Issue Date | FSD Start Date | Milestone I to FSD Start (months) | Requirement Date to FSD Start (months) |
|---|---|---|---|---|---|
| Missiles | | | | | |
| Matador | 8/45 | | 6/47 | 26 | |
| Navaho | 4/46 | | 3/52 | 71 | |
| Falcon | 3/47 | 11/47 | 3/48 | 12 | 4 |
| Bomarc | 1/50 | | 1/51 | 12 | |
| Quail | 10/53 | 3/53 | 4/55 | 18 | 25 |
| Mace | | 10/54 | 1/56 | | 15 |
| Hound Dog | | 3/56 | 8/57 | | 17 |
| Skybolt | 7/57 | 1/59 | 2/60 | 31 | 13 |
| SRAM | 4/63 | 3/64 | 10/66 | 42 | 31 |
| Maverick | 6/66 | 7/64 | 7/68 | 25 | 48 |
| Harpoon | 11/70[a] | | 5/73 | 30 | |
| ALCM/SLCM | 2/74[a] | | 1/77 | 35 | |
| Pershing II | 1/74[a] | | 12/78 | 59 | |
| Other Systems[b] | | | | | |
| UTTAS/UH-60 | 5/71[a] | | 5/71 | 0 | |
| TACTAS | 5/73[a] | | 6/73 | 1 | |
| EF-111A | 10/74[a] | | 1/75 | 3 | |
| CH-53 | 10/71[a] | | 4/75 | 42 | |
| Aegis(ship) | 11/74[a] | | 6/76 | 19 | |
| XM-1 | 11/72[a] | | 11/76 | 48 | |
| DSCS III | 12/74[a] | | 12/76 | 24 | |
| AAH/AH-64 | 9/72[a] | | 12/76 | 51 | |
| DIVAD Gun | 2/77[a] | | 1/78 | 11 | |
| MX | 3/76[a] | | 12/78 | 33 | |
| NAVSTAR | 12/73[a] | | 6/79 | 54 | |

[a]Actual DSARC I review date.

[b]This set includes all other systems that have actually passed through both DSARC I and II reviews. Poor documentation made it impossible to include the helicopters shown in Table 1 in this part of the analysis.

no attempt was made to calculate a trend over time. However, the average duration of the intervals shown in Fig. 2 is 24 months, and the average time required to move from Milestone I to the beginning of full-scale development (see the following section) was 32 months. The obvious conclusion is that in programs starting before the issuance of OMB circular A-109 it was common practice to process the formal requirements document *after* the initiation of what we now would call Phase I studies. In comparison, today's policy clearly calls for those two activities to occur in series. That is, a MENS must be approved before even the Phase Zero studies can begin, and thus today the MENS would typically appear one to two years before Milestone I.

How should we interpret the disparity in timing between the modern MENS and the older requirements document? Clearly the two did not serve identical functions. The MENS addresses only the question of operational need, whereas the typical requirements document of the old days included some degree of system description and performance specification. However, a careful review of many program histories leads to a strong cumulative impression that the equivalent of Phase I studies was frequently initiated on a speculative basis, long before a consensus was forged on overall military need. Indeed, that very practice of "uncontrolled" concept formulation and advanced technology development was one factor leading to the formulation of Circular A-109.

If the requirements formulation is to be completed before start of Phase Zero, as specified in the current regulations, the overall planning phase will inevitably be lengthened. However, some flexibility is usually observed in the application of such regulations, so it is useful to examine our limited experience with Phase Zero.

We reviewed several currently active programs in an attempt to gain some insight into the typical duration of Phase Zero as it is currently being managed. Specifically, dates were sought for the following milestones:

1. Approval for the first formal statement of need for a new capability within the Service. Such a document is frequently issued by an operating command, and constitutes a request by that command addressed to the Service headquarters. It is normally the first identifiable step in the process that leads to the drafting of a MENS and its submission to OSD for approval.
2. MENS approval by OSD.
3. The start of formal Phase Zero studies (normally conducted by contractors) to examine alternative approaches to satisfying the mission need defined in the MENS.
4. Milestone I DSARC review.

Although OMB circular A-109 was issued in 1976, and the implementing versions of DoD Directives 5000.1 and 5000.2 were issued in early 1977, major procedural changes of that sort take some time to become established as routine activities. Furthermore, service action officers kept sparse records when formulating and processing the first few MENS and it proved impossible to assemble any orderly and significant body of data on the actual time intervals involved. Preliminary evidence suggests that it is possible to spend several years moving through this phase (that is, from the first service level approved requirement to Milestone I review), but that may simply reflect the newness of the procedures. For example, the practice of not requesting from Congress the funds needed for Phase Zero studies until the MENS has been approved has sometimes created a "dead time"

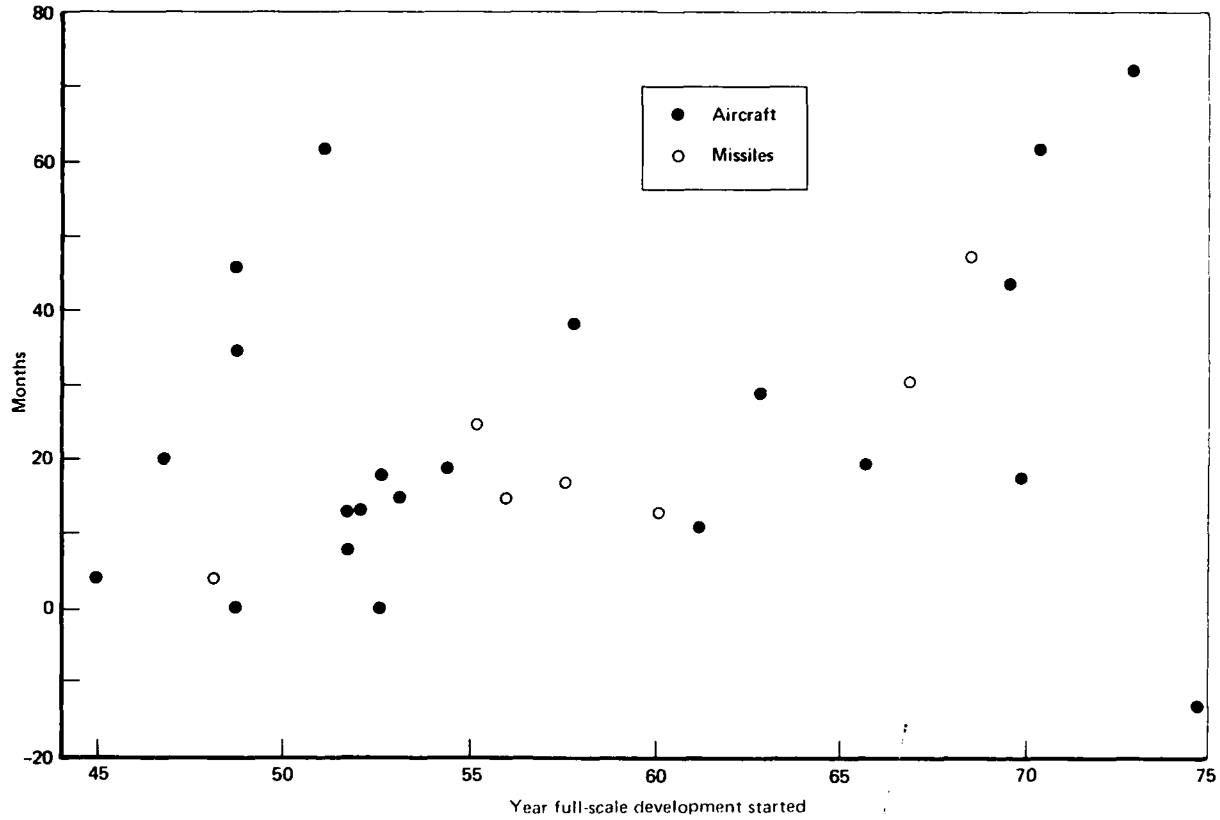


Fig. 2—Interval from formal requirement to FSD

of six to 12 months merely because the budget cycle and the DSARC cycle were not in phase. Such delays do not occur in every case, but they have occurred in some cases. Further experience with the procedures may reduce delays of that type. Section IV contains a further discussion of this subject.

## CONCEPT VALIDATION

As noted earlier, the only pre-Milestone II event that could be unambiguously identified and tracked was the issuance of a formal requirement for the system. Other events, such as contracts for funded studies, decision directives from senior officials, etc. were found to be nearly useless for purposes of analysis because of poor documentation. Consequently, we decided to construct a synthetic milestone that would correspond to today's Milestone I review. We examined each program and estimated when the Milestone I review would have occurred if the current DoD management process had been in force when that program was evolving. This imperfect process calls for some difficult judgments, but it seemed the only way to get a milestone that could be consistently applied to the many older programs and that could be compared with current milestones.

For those unfamiliar with the DSARC milestone review, the following excerpts will help to define the timing and intent of the Milestone I review.

> *Milestone I—Demonstration and Validation.* When the DoD Component completes the competitive exploration of alternative system concepts to the point where the selected alternatives warrant system demonstration, the DoD Component Head shall request approval to proceed with the demonstration and validation effort. [DoDD 5000.1, Jan. 18, 1977, Paragraph IV.D.2.]

> As a result of the competitive identification and exploration of alternative design concepts, the DoD Component Head may conclude that the demonstration and validation phase should (1) involve several alternatives; (2) be limited to a single system concept; (3) involve alternative subsystems only and not be conducted at the system level; or (4) there should be no demonstration and the program should proceed directly into full-scale engineering development. [DoDD 5000.2, Jan. 18, 1977, Paragraph IV.E.2.]

The dates selected for the equivalent of a Milestone I review are shown in Table 2. For some programs it was very difficult to establish with any confidence when a Milestone I review would have been conducted, so those systems (principally helicopters) are deleted from the table. Conversely, 12 additional systems were introduced—those that actually passed through both a Milestone I and a Milestone II review.[11] Those systems are a mixed lot but constitute most of the 1970s data against which the 1950s and 1960s can be measured.

The duration of Phase I, as plotted in Fig. 3, displays a lot of scatter. However, unlike the requirements data shown earlier, we were able to select an equivalent

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[11]Of the 80-plus systems that have received some sort of formal DSARC review during the past decade, only 17 have passed through both a Milestone I and a Milestone II review. Of the remainder, over half went directly to a Milestone II with no prior review, a few were canceled or substantially revised after Milestone I, and the others are now proceeding through Phase I.

Milestone I date in a reasonably systematic manner and it should be possible to draw some inferences regarding long-term trends.

We used two approaches to test for a long-term trend. First, we ran a series of linear least-squares regressions on several variants of the data base. Our objective was mainly to see if there had been a cumulative change over the several-decade period. The large amount of scatter and the skewed distribution of the data discouraged use of a higher-order model.

The first test was with the most homogeneous data set that contained a significant number of entries—fighter and attack aircraft. That yielded a positive slope of ten months per decade, with a t-statistic significance probability of 1 percent.[15] Next, we ran a regression with the entire aircraft sample, which yielded a slope of seven months per decade and a significance probability of 9 percent. In a third run, we added the missile systems to the entire aircraft sample, yielding a positive slope of six months per decade with a significance probability of 3 percent.

One interesting feature of the data shown in Fig. 3 is that large strategic systems appear to require exceptionally long planning periods. The four highest points in the 1950 decade represent the B-47, B-52, Navaho, and B-58, and the highest point in the 1970s represents the B-1. If those systems are removed from the sample, the slope of the fitted line becomes 10 months per decade, with a significance probability of less than 1 percent.

Finally, the entire sample shown in Table 2 was pooled. It might be argued that such disparate systems as aircraft, missiles, helicopters, satellites, and tanks should not be included in the same sample. However, we are dealing here with *decision* time, and there is some basis for arguing that in most cases it takes roughly the same length of time to decide on the merits of a major weapon system regardless of type. The regression on the pooled sample yielded a positive slope of four months per decade and a significance probability of 16 percent. Regardless of arguments on the validity of such a pooled sample, the large significance probability would suggest placing little confidence in the results of that regression.

The results of the regression analysis for the somewhat homogeneous sample of aerospace systems are quite strong.[16] The duration of Phase I in a typical program of the 1970s was one to two years longer than that of our estimated "equivalent" Phase I for programs of the 1950s. However, further analysis was needed to learn if that growth was a uniform trend or if it could be related to particular events or changes in management style.

Recognizing that most interest centered on whether the 1970s experience was different from that of earlier times, we divided the data into two sets—systems with

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[15]In all statistical tests of this type, our null hypothesis is that the slope of the regression line is zero (that there was no change in the interval over time). The significance probability shown is essentially the probability that the null hypothesis could be true, based on a one-tailed statistical test. In the present case there is less than 1 percent chance that the estimated slope would be as large as ten months per decade if the interval had actually not changed over time.

[16]The data quoted above were computed using the *end* of the interval (Milestone II) as the independent variable. This may be considered a slightly unorthodox procedure, so the regressions were repeated with the beginning of the interval as the independent variable. Results were identical to the earlier set for the most homogeneous sample (fighter and attack aircraft only). The other variants of the sample yielded roughly comparable values of trend slope but with poorer statistical significance than the initial calculations. This is an example of a situation, noted elsewhere in the report, that seemingly robust statistical results can be changed to a significant degree by small changes in sample or in experiment design.

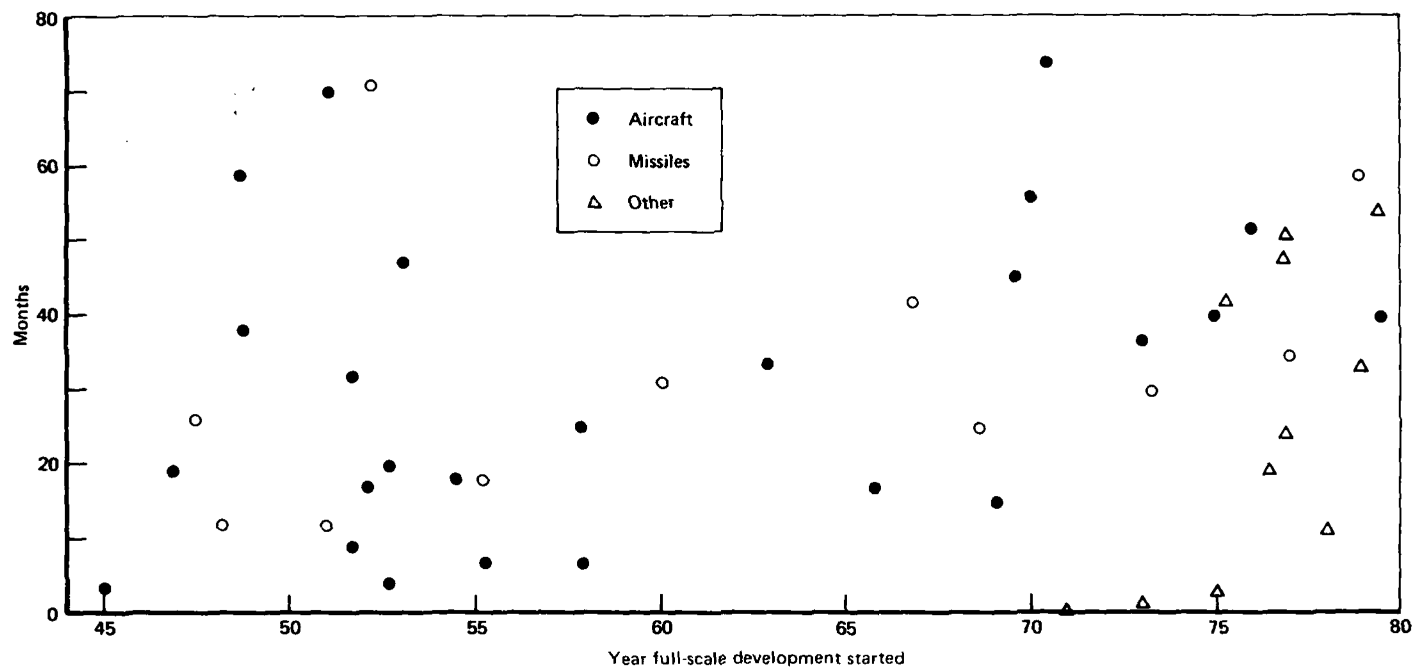


Fig. 3—Duration of concept formulation and validation phase

FSD beginning before or after 1970—and compared the two sets.[15] Again we conducted three separate tests: for aircraft systems only; aircraft plus missiles; and aircraft, missiles, and other 1970s systems together. The results are shown in Table 3.

Table 3

COMPARISON OF PHASE I DURATIONS
(months)

| Sample | Time Period | | | |
|---|---|---|---|---|
| | Pre-1970 | Post-1970 | Pre-1960 | Post-1960 |
| Aircraft Only | | | | |
| Sample size | 21 | 5 | 15 | 11 |
| Mean phase duration | 27 | 49 | 25 | 39 |
| Median duration | 19 | 40 | 19 | 40 |
| Standard deviation | 19 | 15 | 20 | 18 |
| Significance probability[a] | 2% | | 5% | |
| Aircraft and Missiles | | | | |
| Sample size | 29 | 8 | 20 | 17 |
| Mean phase duration | 27 | 46 | 26 | 38 |
| Median duration | 20 | 40 | 18 | 37 |
| Standard deviation | 19 | 16 | 21 | 16 |
| Significance probability[a] | 0.5% | | 1% | |
| All Programs | | | | |
| Sample size | 29 | 19 | 20 | 28 |
| Mean phase duration | 27 | 34 | 26 | 33 |
| Median duration | 20 | 37 | 18 | 35 |
| Standard deviation | 19 | 21 | 21 | 19 |
| Significance probability[a] | 10% | | 5% | |

[a]Based on the Mann-Whitney test.

Examining different parts of the sample provides different conclusions. If we examine the history of aerospace systems alone, we find that during the 1970s the average duration of Phase I was 70 to 80 percent greater than during the previous two decades. A statistical test yields a very high confidence that the sample distributions are truly different (less than 2 percent chance of incorrectly rejecting the null hypothesis of no difference in phase duration).

When all 1970s programs in our sample are compared with the aircraft and

[15]We used the Mann-Whitney nonparametric test to compare the distributions of the two samples because in many of the examples the distributions were badly skewed.

missiles of the 1950s and 1960s (admittedly a mixed sample), we find that the difference in mean phase duration was substantially decreased, and the conclusion that the two sample distributions are different carries a 10 percent chance of being incorrect. However, it can be seen from Table 2 that three of the systems (UH-60, TACTAS, and EF-111A) proceeded through Phase I in three months or less. That is clearly inadequate to conduct normal Phase I studies, so we conclude that those data points must represent largely administrative decisions. Eliminating them from the sample changes the post-1970 mean phase duration from 34 to 40 months (a 50 percent increase over the pre-1970 mean), and the two distributions can be claimed to be different with a significance probability of less than 1 percent.

To test the effect of the major change in acquisition management that occurred in the early 1960s, we moved the division line in our sample, comparing pre-1960 and post 1960 events. Results are shown in Table 3. The results are remarkably similar to those obtained when the sample was split at 1970. For aerospace systems the mean phase duration for the 1960s and 1970s together is about 50 percent greater than that of the 1950s, and the sample distributions can be claimed to be different with a probability of error of not more than 5 percent. Using the entire sample, we find the difference in mean phase duration is reduced to 25 percent, and the significance probability is 5 percent. But when the three exceptional data points of the 1970s (UH-60, TACTAS, and EF-111A) are removed, the mean duration of the later period is 40 percent greater than for the earlier, and the significance probability is less than 1 percent. Clearly, the 1950s were different from the later periods. However, the subsequent growth in Phase I interval appears to be distributed between the 1960s and the 1970s, and we find little evidence that the observed trend toward increasing duration of Phase I can be linked uniquely to management changes made at the beginning of the 1970s.

Finally, we examined the set of systems passing through both Milestones I and II during the 1970s (note (b) in Table 2) to see if any intra-decade trends could be identified. The sample was arranged into chronological order and separated into two equal parts, first according to Milestone I date and then according to Milestone II date, and in each case the two halves were compared. Results are shown in Table 4. The comparison depends on which milestone is used to separate the data set into two parts; one way shows the *early* systems to have taken longer, the other way shows the *later* systems to have taken longer. With that result, statistical tests seemed unnecessary and we conclude that this comparison provides no basis for asserting the existence of any trends within the decade.

When interpreting the data and analysis results presented in this section, one should remember that the data are sparse, widely scattered, and in some cases involve a pooling of diverse kinds of weapon systems. Many factors other than management policies affect the duration of the planning phase. Nevertheless, we believe two conclusions are justified:

1. OMB Circular A-109 clearly changed the role of requirements formulation in the planning phase. Whereas the earlier practice had often been to start concept formulation and exploratory development work before a requirement was issued, present policy calls for an approved requirement before any such work can start. Very preliminary data suggest that this may have added a significant amount of time to the planning phase (measured

Table 4

PHASE I TRENDS IN THE 1970S

| | Mean Interval Duration (months) | |
|---|---|---|
| Basis of Sample Division | First Half | Second Half |
| According to DSARC I date | 38 | 28 |
| According to DSARC II date | 27 | 39 |

in years rather than months), but measurement difficulties render that conclusion highly tentative.

2. There are strong indications that the portion of the planning phase now characterized as Phase I (the interval between Milestones I and II reviews) has been growing at the average rate of 6 to 10 months per decade, and Phase I durations for aerospace system developments in the 1970s appear to average from 50 to 80 percent greater than those of the 1950s. However, it also appears that the major change in Phase I durations occurred between the 1950s and the 1960s and that only a modest additional increase occurred in the 1970s. There is little evidence to suggest that the large changes since the 1950s can be directly and uniquely related to any of the management changes at the beginning of the 1970s.

# III. HARDWARE DEVELOPMENT AND PRODUCTION PHASE

After the beginning of full-scale hardware development, the documentation of a program becomes more complete and readily available. In the present study we were able to measure three milestones: first flight, delivery of first operational unit, and delivery of 200th unit. We are interested in learning how long it takes to proceed from the beginning of major hardware development to each of those three milestones. The time required to produce the first 200 operational units was also assessed separately. Results are summarized in Tables 5, 6, and 7.

The fixed-wing aircraft (Table 5) constitute the majority of this sample. In this case, it seemed unreasonable to include dissimilar systems in the same data set when we were measuring the time required to develop, test, and manufacture a system. Although there is no obvious reason why it should take longer to reach a *decision* regarding, say, a helicopter system than an aircraft system, there may well be reasons why the *hardware development* of one class of system would take longer than that for another class. Finally, the interval data for missiles and helicopters were much more sparse and scattered than for aircraft. Therefore, the analysis discussed below is restricted to the sample of aircraft, although milestones for the other systems are recorded in Tables 6 and 7.

Several sources of complexity in the data deserve discussion. The principal one is that some of the aircraft programs started with a prototype phase before the full-scale system development phase. This raises the question of when the "development" interval really started: Was the prototype phase part of the planning process or part of the development process? In general, we prefer to treat prototype development as part of the planning phase (as was done in Section II of this report) because the start of FSD has been widely viewed as the critical decision involving the first commitment of major resources to the program. However, we recognize that such an interpretation is not universely accepted so we show development-phase data for both interpretations. For programs involving a prototype phase Table 5 shows two lines. The first line (with a "P" following the system designation) shows data for the prototype phase in cols. (1) thru (4), and with the subsequent intervals (cols. (5) and (7)) measured from the start of the prototype phase. The second line shows the full-scale system development phase, with subsequent intervals measured from the start of FSD. Sometimes, especially in the earlier programs, full-scale development was started before the prototype had been brought to flight status.

This approach still leaves some difficult decisions to be made because the relationship between a prototype and a subsequent full-scale development program is not always clear. For example, was the F-88 a prototype of the F-101? In this study the lineage between the two designs was not considered to be that direct because different engines were used, there were substantial differences in planform and other design features, and the empty weight of the F-101 was roughly twice that of the F-88. The YF-17, however, was treated as a prototype of the F-18 because the similarity in configuration and size between the two designs was of the same

Table 5

ACQUISITION INTERVALS FOR SELECTED AIRCRAFT SYSTEMS

| Model | | Development Start Date (1) | First Flight Date (2) | Months to First Flight (3) | First Operational Delivery (4) | Months to First Delivery (5) | 200th Operational Delivery (6) | Months to 200th Delivery (7) | Time to Produce 200 a/c (8) |
|---|---|---|---|---|---|---|---|---|---|
| F-84 | P | 11/44 | 2/46 | 15 | 6/47 | 31 | 4/48 | 41 | 10 |
| F-84 | | 1/45 | 1/47 | 24 | 6/47 | 29 | 4/48 | 39 | 10 |
| F-86 | P | 5/45 | 10/47 | 29 | 5/48 | 36 | 10/49 | 53 | 17 |
| F-86 | | 12/46 | 5/48 | 17 | 5/48 | 17 | 10/49 | 34 | 17 |
| F3D | P | 4/46 | 3/48 | 23 | 8/50 | 52 | 4/53 | 84 | 32 |
| F3D | | 6/48 | 2/50 | 20 | 8/50 | 26 | 4/53 | 58 | 32 |
| F-89 | P | 6/46 | 8/48 | 26 | 9/50 | 51 | 1/54 | 91 | 40 |
| F-89 | | 10/48 | 6/50 | 20 | 9/50 | 23 | 1/54 | 63 | 40 |
| F-94 | | 10/48 | 7/49 | 9 | 12/49 | 14 | 4/51 | 30 | 16 |
| F4D | P | 12/48 | 1/51 | 25 | 5/55 | 77 | 8/57 | 104 | 27 |
| F4D | | | 6/54 | | 5/55 | | 8/57 | | 27 |
| F-100 | P | 10/51 | 5/53 | 19 | 10/53 | 24 | 7/55 | 45 | 21 |
| F-100 | | 2/52 | 10/53 | 20 | 10/53 | 20 | 7/55 | 41 | 21 |
| F-101 | | 10/51 | 9/54 | 35 | 5/57 | 67 | 5/58 | 79 | 12 |
| F-102 | | 9/51 | 10/53 | 25 | 6/55 | 45 | 1/57 | 64 | 19 |
| F-104 | P | 3/53 | 2/54 | 11 | 1/57 | 46 | 12/58 | 69 | 23 |
| F-104 | | 7/54 | 2/56 | 19 | 1/57 | 30 | 12/58 | 53 | 23 |
| F-105 | | 9/52 | 10/55 | 37 | 5/58 | 68 | 4/61 | 103 | 35 |
| F-106 | | 11/55 | 12/56 | 13 | 6/58 | 31 | 4/60 | 53 | 22 |
| F-4 | | 5/55 | 5/58 | 36 | 12/60 | 67 | 10/62 | 89 | 22 |
| F-111 | | 12/62 | 12/64 | 24 | 4/67 | 52 | 12/69 | 84 | 32 |
| F-14 | | 2/69 | 12/70 | 22 | 5/72 | 39 | 7/76 | 89 | 50 |
| F-15 | | 12/69 | 7/72 | 31 | 11/74 | 59 | 7/77 | 91 | 32 |
| F-16 | P | 4/72 | 2/74 | 22 | 8/78 | 76 | 1/81 | 105 | 29 |
| F-16 | | 1/75 | 12/76 | 23 | 8/78 | 43 | 1/81 | 72 | 29 |
| F-18 | P | 4/72 | 6/74 | 26 | 5/80 | 97 | | | |
| F-18 | | 1/76 | 11/78 | 34 | 5/80 | 52 | | | |

Table 5—continued

| Model | Development Start Date (1) | First Flight Date (2) | Months to First Flight (3) | First Operational Delivery (4) | Months to First Delivery (5) | 200th Operational Delivery (6) | Months to 200th Delivery (7) | Time to Produce 200 a/c (8) |
|---|---|---|---|---|---|---|---|---|
| A3D P | 3/49 | 10/52 | 43 | 1/55 | 70 | 6/60 | 135 | 65 |
| A3D | | 9/53 | | 1/55 | | 6/60 | | 65 |
| A-4 | 6/52 | 6/54 | 24 | 8/55 | 38 | 12/57 | 66 | 28 |
| A-5 | 6/56 | 8/58 | 26 | 2/60 | 44 | | | |
| A-6 | 1/58 | 4/60 | 27 | 4/62 | 51 | 2/67 | 109 | 58 |
| A-7 | 3/64 | 9/65 | 18 | 3/66 | 24 | 1/68 | 46 | 22 |
| A-10 P | 12/70 | 5/72 | 17 | 11/75 | 59 | 5/79 | 101 | 42 |
| A-10 | 1/73 | 2/75 | 25 | 11/75 | 34 | 5/79 | 76 | 42 |
| B-47 P | 10/45 | 12/47 | 26 | 12/50 | 62 | 6/52 | 80 | 18 |
| B-47 | 9/48 | 6/50 | 21 | 12/50 | 27 | 6/52 | 45 | 18 |
| B-52 P | 7/48 | 4/52 | 45 | 1/55 | 78 | 8/57 | 109 | 31 |
| B-52 | 2/51 | 8/54 | 42 | 1/55 | 47 | 8/57 | 78 | 31 |
| B-58 | 2/53 | 11/56 | 45 | 11/59 | 81 | | | |
| B-70 | 12/57 | 9/64 | 81 | Project canceled during development | | | | |
| B-1 | 6/70 | 12/74 | 54 | Project canceled during development | | | | |
| C-130 P | 7/51 | 8/54 | 37 | 12/55 | 53 | 2/59 | 91 | 38 |
| C-130 | 9/52 | 4/55 | 31 | 12/55 | 39 | 2/59 | 77 | 38 |
| KC-135P | 5/52 | 7/54 | 26 | 1/57 | 56 | 1/59 | 80 | 24 |
| KC-135 | 8/54 | 8/56 | 24 | 1/57 | 29 | 1/59 | 53 | 24 |
| C-133 | 2/53 | 4/56 | 38 | 8/57 | 54 | | | |
| P-3 | 4/58 | 11/59 | 19 | 3/62 | 47 | 12/66 | 104 | 57 |
| C-141 | 4/61 | 12/63 | 32 | 10/64 | 42 | 4/67 | 72 | 30 |
| C-5 | 10/65 | 6/68 | 32 | 10/69 | 48 | | | |
| S-3A | 8/69 | 1/72 | 29 | 10/73 | 50 | | | |

(1) Formal start of aircraft development. Usually denoted by issuance of a contract, but sometimes by source selection when formal contract ratification was delayed but design work continued. The date shown applies to start of actual hardware design and development, not to the usual design studies that precede actual development. Occasionally (B-58, for example) a development program was started, then canceled, redirected, and restarted. The last such start is noted in the table.

Table 5—continued

(2) Date of first flight of the very first flight article to emerge from the specified development project.

(3) (2) - (1), in months.

(4) Date at which the first fully operational configuration was accepted by the using service for operational inventory (as opposed to development testing). Note that this does not coincide with IOC, which usually implies delivery of several aircraft to the using command, while the first operational aircraft may well go to a training unit. The intent here was to mark a milestone in the system development program, not to measure establishment of a true operational capability.

(5) (4) - (1), in months.

(6) Date of delivery of the 200th operational item (again excluding the units produced for development testing).

(7) (6) - (4), in months.

(8) (6) - (1), in months.

Table 6

ACQUISITION INTERVALS FOR SELECTED MISSILE SYSTEMS[a]

| Model | Development Start Date (1) | First Flight Date (2) | Months to First Flight (3) | First Operational Delivery (4) | Months to First Delivery (5) |
|---|---|---|---|---|---|
| Matador | 6/47 | 1/49 | 19 | 6/52 | 60 |
| Falcon | 3/48 | 5/51 | 38 | 11/54 | 80 |
| Bomarc | 1/51 | 9/52 | 20 | 4/59 | 99 |
| Navaho | 3/52 | 11/56 | 56 | Canceled during development | |
| Quail | 4/55 | 8/58 | 40 | | |
| Mace | 1/56 | 2/58 | 25 | 11/60 | 58 |
| Hound Dog | 8/57 | 4/59 | 20 | 12/59 | 28 |
| Skybolt | 2/60 | 4/62 | 26 | Canceled during development | |
| SRAM | 10/66 | 7/69 | 33 | | |
| Maverick | 7/68 | 8/69 | 13 | 12/72 | 53 |
| Harpoon | 5/73 | | | | |
| ALCM/SLCM | 1/77 | | | | |
| Pershing II | 12/78 | | | | |

[a]See notes to Table 5 for explanation of column headings.

Table 7

ACQUISITION INTERVALS FOR SELECTED HELICOPTER SYSTEMS[a]

| Model | | Development Start Date (1) | First Flight Date (2) | Months to First Flight (3) | First Operational Delivery (4) | Months to First Delivery (5) |
|---|---|---|---|---|---|---|
| UH-43 | | 6/50 | 9/56 | 75 | 4/58 | 94 |
| HH-52 | P | | 5/58 | | | |
| HH-52 | | 2/62 | | | 1/63 | 11 |
| SH-34 | P | 6/52 | 3/54 | 21 | 9/54 | 27 |
| UH-1 | P | 6/55 | 10/56 | 16 | | |
| UH-1 | | ?57 | 2/58 | | 6/59 | |
| SH-3 | | 9/57 | 3/59 | 18 | 9/61 | 48 |
| UH-2 | | 11/57 | 7/59 | 20 | 12/62 | 61 |
| CH-46 | P | | 4/58 | | | |
| CH-46 | | 7/58 | 10/60 | 27 | 5/61 | 34 |
| CH-47 | P | 6/59 | 9/61 | 27 | | |
| CH-47 | | | | | 8/62 | |
| OH-6 | P | 5/61 | 12/62 | 19 | | |
| OH-6 | | 5/65 | | | 9/66 | 16 |
| CH-53 | P | 8/62 | 10/64 | 26 | | |
| CH-53 | | 8/63 | | | 6/66 | 34 |
| CH-54 | P | | 5/62 | | | |
| CH-54 | | 6/63 | | | | |
| AH-1 | P | 3/65 | 9/65 | 6 | | |
| AH-1 | | 4/66 | | | 6/67 | 14 |
| OH-58 | P | | 1/66 | | | |
| OH-58 | | 3/68 | | | 5/69 | 14 |
| UH-60 | | 8/72 | 10/74 | 26 | 10/78 | 74 |
| AH-64 | P | 6/73 | 9/75 | 27 | | |
| AH-64 | | 12/76 | | | | |

[a]In many cases the development of commercial and military versions of a particular helicopter model was intermingled, complicating interpretation of the data in this table. Additional information is contained in Appendix B.

See notes to Table 5 for explanation of column headings.

order as other prototype-to-operational configurations in the sample.[18] To aid in the identification of time trends, the four intervals noted above were plotted against calendar time. Figure 4 shows time to first flight for the entire sample. Prototypes are shown as open circles, and the FSD phase of programs without prototypes are shown as solid circles. The FSD phase of a system that had been previously prototyped is not shown, so that each system is represented only once on the figure.

The data in this figure contains considerable scatter, and any least squares regression analysis must be treated with some reservations, but the result is a line of essentially zero slope. Because of the wide variety of aircraft contained in the sample, one immediately suspects that some of the scatter may be due to mixing of bomber, cargo, attack, and fighter aircraft together. In Fig. 5 only fighter and attack aircraft are shown, and this does reduce the scatter somewhat. The regression analysis again yields a line of nearly zero slope, and the statistics offer no basis for any other interpretation. A visual inspection shows little change in average time to first flight over the span of three decades.

Figures 6 and 7 show time to delivery of the first operational item. As in Figs. 4 and 5 a distinction is made between systems that started with a prototype phase and all others. In Fig. 6 all intervals were calculated from the earliest start date—from the start of the prototype phase if there was one, otherwise from the start of FSD. This interpretation essentially treats the prototype phase as part of the development phase. In Fig. 7 the intervals were calculated from the beginning of FSD (the prototype phase was excluded).[19] A regression analysis of the full sample shown in Fig. 6 yielded a slope of four months per decade, but the corresponding significance probability of 34 percent indicates there is no confident evidence for the assumption of a change in interval over time. Furthermore, if the somewhat anomalous F-18 is deleted,[20] the slope goes to zero. The data in Fig. 7 yielded a slope of five months per decade, but with a significance probability of 15 percent. When the sample was restricted to only fighter and attack types the analysis yielded a slope of seven months per decade (Fig. 6) and five months per decade (Fig. 7). Again the significance probability was fairly large (10 to 15 percent) and a visual inspection shows little evidence of strong trends.

We conclude from this analysis that although the regression tests suggest a change in interval duration of several months per decade, the large significance probability associated with all of the tests suggests some caution in asserting that any real change has occurred. Because the difference between this interval and the time to first flight discussed above is largely devoted to production and testing of an initial set of units (in preparation for start of production for operational use), there is little basis for claiming that recently increased emphasis on testing prior to production go-ahead (Milestone III) has significantly lengthened the time required to deliver the first operational unit.

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[18]The change in designation, from F-17 to F-18, was an OSD initiative

[19]Another interesting result suggested by Fig. 7 is that systems preceded by a prototype phase tended to move through subsequent FSD rather more quickly than all others.

[20]Although the F-18 has technical roots in the YF-17 Lightweight Fighter Program, it was really not started as an independent weapon system development program until some time after the prototype program was completed. Therefore, when measured against the beginning of the prototype phase the F-18 shows an artificially long development program

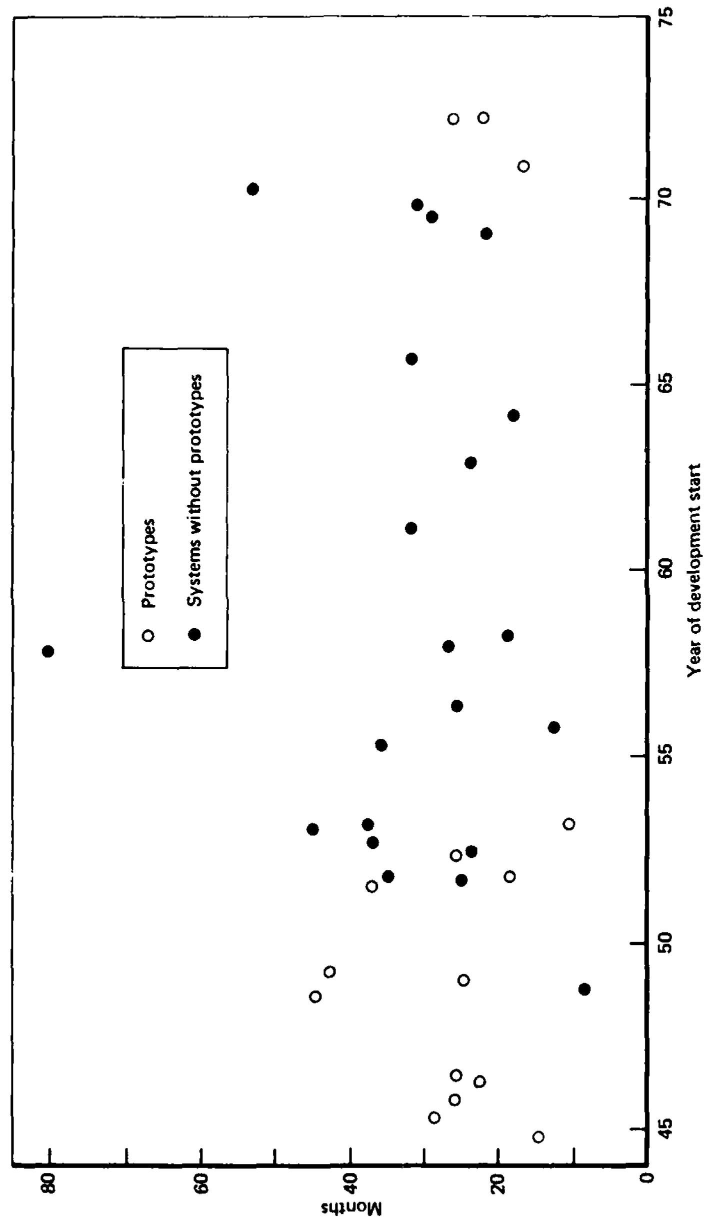


Fig. 4—Time to first flight

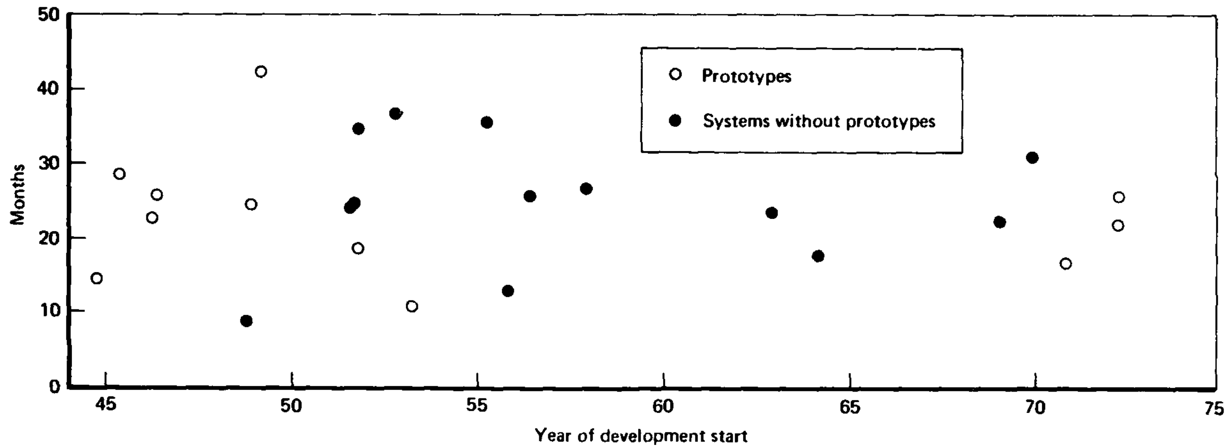


Fig. 5—Time to first flight, fighter and attack types only

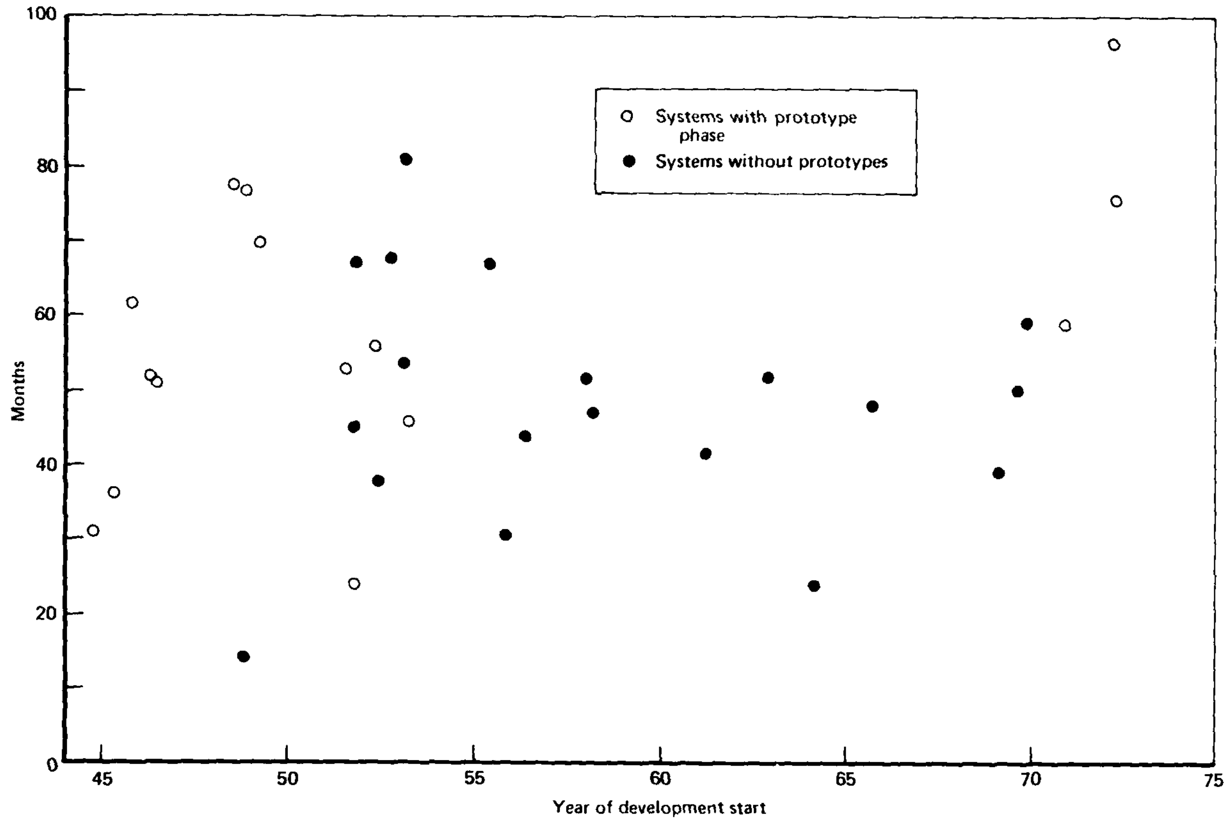


Fig. 6—Time to first operational delivery measured from earliest development start

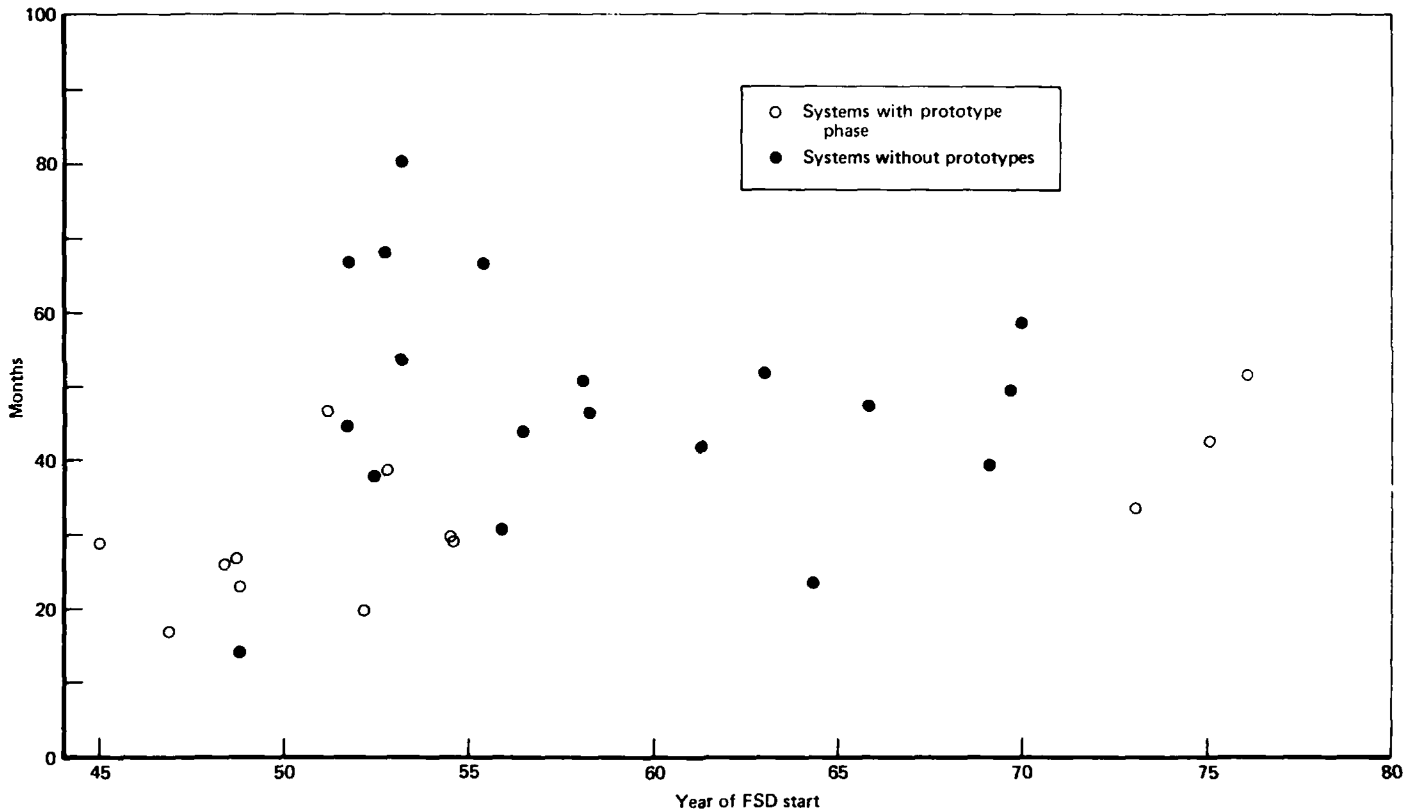


Fig. 7—Time to first operational delivery measured from start of FSD

Figures 8 and 9 show time to delivery of the 200th operational item. As in the previous case, Fig. 8 shows all intervals measured from the earliest development start date, and Fig. 9 shows intervals measured from the beginning of FSD. Although analysis of the data in Fig. 8 yielded results of low statistical significance, a linear regression of the data in Fig. 9 produced a line with a slope of 12 months per decade and a significance probability of 2 percent. When the sample was limited to fighter and attack types only, the result showed the same slope but with slightly poorer statistical confidence (4 percent rather than the earlier 2 percent). Thus there is a suggestion that this phase has been growing at a rate of one half to one year per decade, but that conclusion is weakened by the poor statistical confidence of the data measured from the earliest start date.

Finally, Fig. 10 shows the time interval between delivery of the first and 200th operational aircraft. Here the data show a pronounced trend toward lower production rates as time progresses. A regression analysis yields a slope of six months per decade, with an 8 percent significance probability. This is not unexpected, because the recent aircraft are up to ten times as expensive (in terms of percent of total available acquisition budget) as those produced in the late 1940s.

To explore the relationship between unit cost and production rate, the unit costs of several aircraft were estimated on a constant-dollar basis (see Appendix D). Results show that for the aircraft in our sample the average investment rate ($/month) per system has actually been increasing over the past three decades. This supports the intuitive notion that production rate is strongly limited by financial resources, and that the lower production rates of recent years can be traced in large part to the increase in average cost of production and operations.

Because of the large scatter in all forms of the interval data, several models were suggested that might yield a better fit. One idea was that aircraft size (weight) or cost might systematically affect the interval, with large, expensive aircraft taking longer to plan and to develop than smaller, cheaper ones. Another hypothesis is that some systems are more technically difficult, and that those take more time to develop than the simpler types. To test these possibilities a multiple regression was performed with aircraft empty weight, unit production cost, a difficulty rating,[21] and the date for FSD start as the independent variables. When analyzed against the time required to move from FSD start to delivery of the first operational unit, and time to delivery of the 200th unit, neither aircraft weight, cost, nor the technical difficulty rating were found to be statistically significant.

Finally, another approach to explanation of the data scatter was based on the suggestion that a complex project would tend to take longer in both the planning and the hardware phases. To normalize for this expected effect, the Phase I duration (from the Milestone I equivalent to beginning of full-scale development) was

[21]Unfortunately, no really satisfactory method has been devised for measuring the technical difficulty of a sample as heterogeneous as that used in the present study. However, two approaches were tried in an attempt to make a first-order test of the hypothesis. First, we conducted a subjective assessment of relative technical difficulty, using the method outlined in Perry, et al., *System Acquisition Strategies*, The Rand Corporation, R-733-PR/ARPA, June 1971. This method calls for assigning to each design a difficulty rating of one to 20, with the higher ratings denoting greater technical difficulty. A second estimate of the technical difficulty of each model was obtained using the method described in W. L. Stanley and M. D. Miller, *Measuring Technological Change in Jet Fighter Aircraft*, The Rand Corporation, R-2249-AF, September 1979.

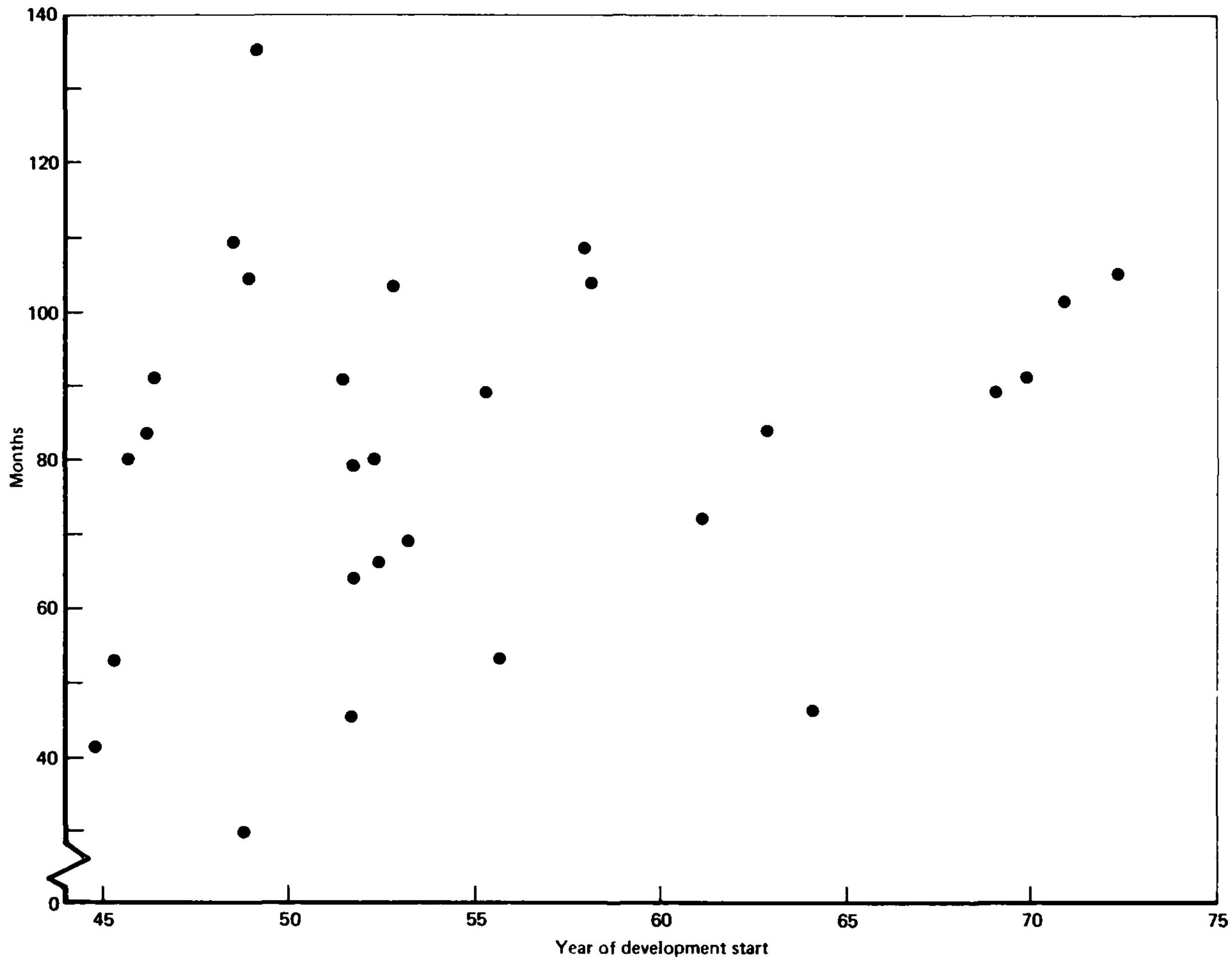


Fig. 8—Time to 200th operational delivery measured from earliest development start

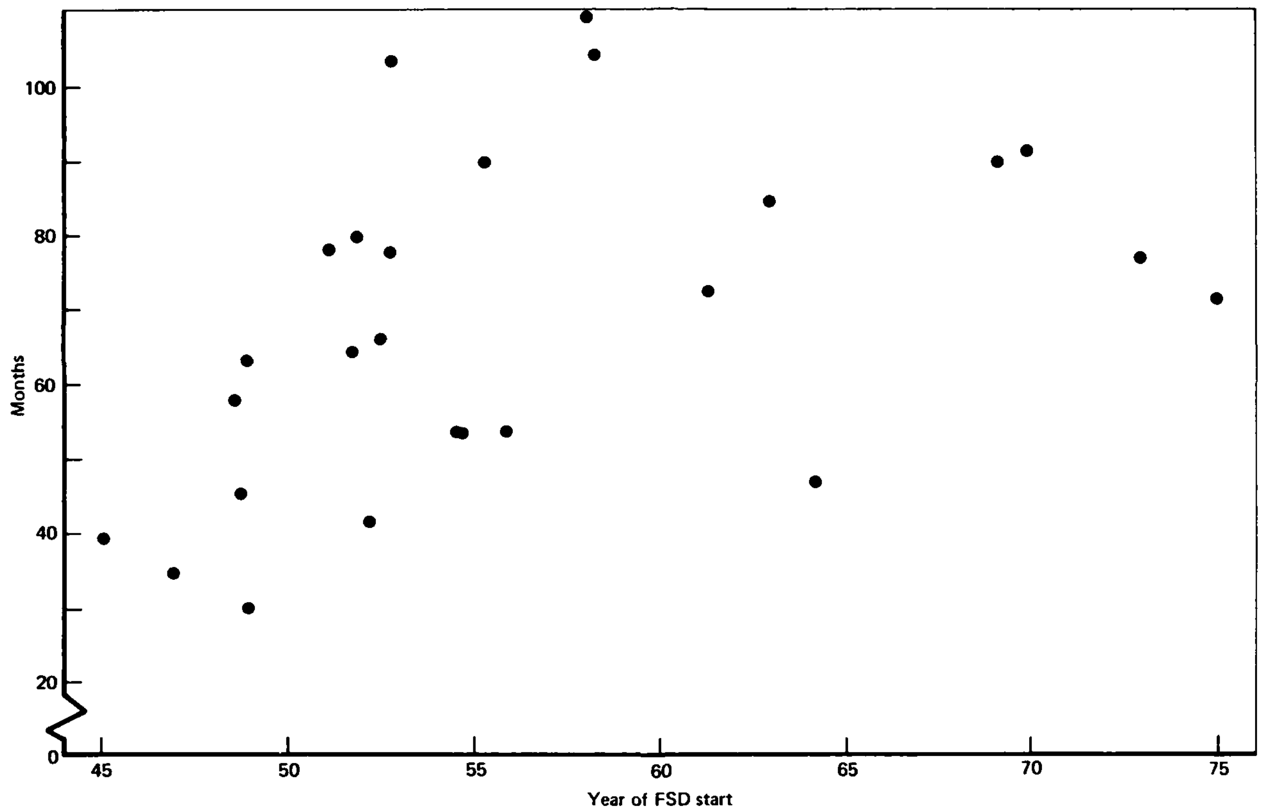


Fig. 9—Time to 200th operational delivery measured from start of FSD

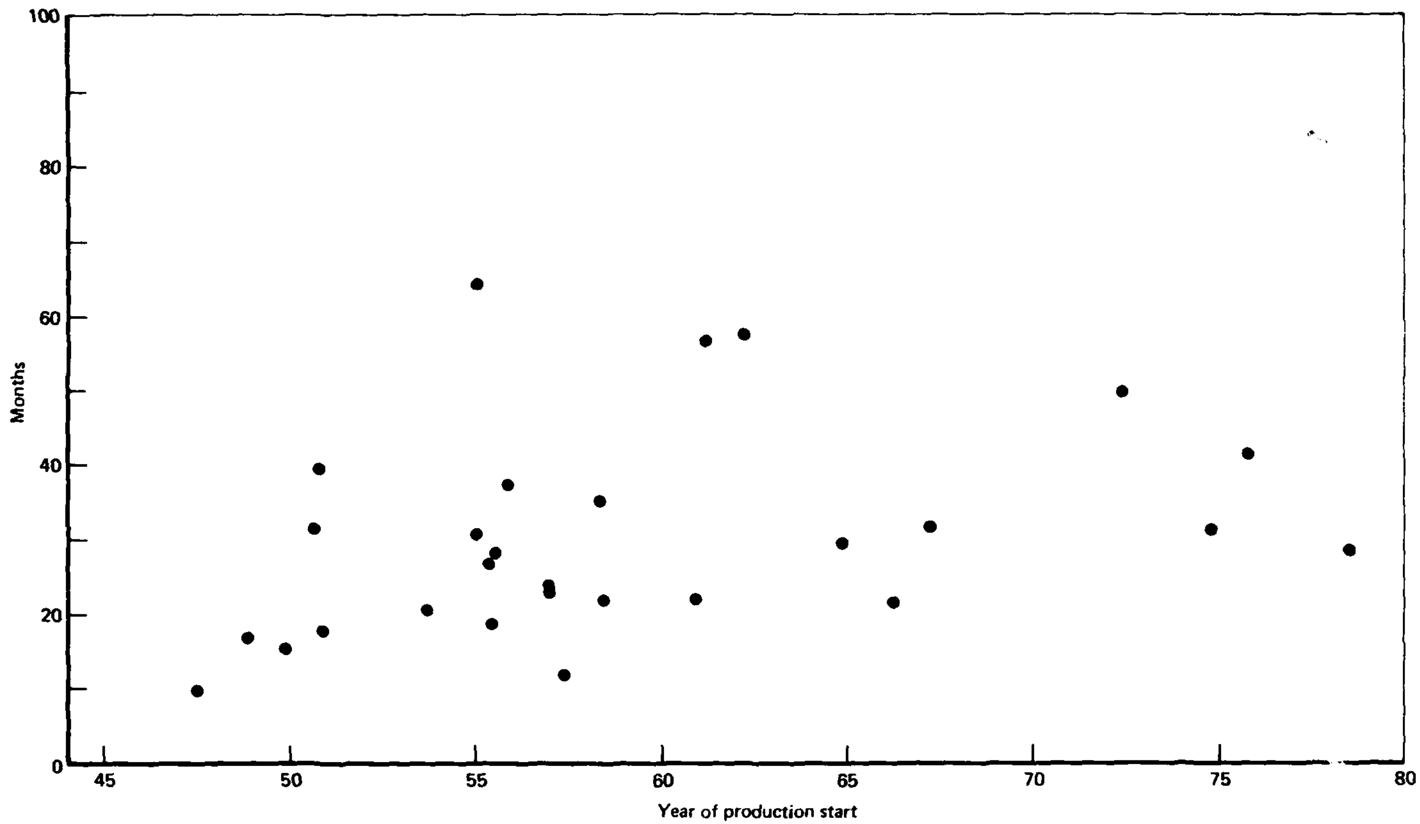


Fig. 10—Time to produce first 200 units

measured as a fraction of total acquisition time (from Milestone I equivalent to delivery of the 200th item). Results are listed in Table 8 and displayed in Fig. 11. As in earlier displays, the data are badly scattered, with a regression yielding insignificant results (i.e., there is no basis for rejecting the null hypothesis of no change over time). Moreover, a visual inspection of Fig. 11 suggests that modern projects are not much different from earlier ones, except in the absence of projects that spent a very small fraction of time in the planning phase. Most projects spend 1/4 to 1/3 of their total acquisition time in the planning phase, a result that intuitively seems reasonable.

Table 8

PHASE I DURATION AS PERCENT OF TOTAL ACQUISITION TIME

| System | FSD Start Date | DSARC I to FSD (months) | FSD to 200th Delivery | Total Time (months) | Percent of Total Time |
|---|---|---|---|---|---|
| F-84 | 1/45 | 3 | 39 | 42 | 7 |
| F-86 | 12/46 | 19 | 34 | 53 | 36 |
| B-47 | 9/48 | 59 | 45 | 104 | 57 |
| F-89 | 10/48 | 38 | 63 | 101 | 38 |
| B-52 | 2/51 | 70 | 78 | 148 | 47 |
| F-102 | 9/51 | 32 | 64 | 96 | 33 |
| F-101 | 10/51 | 9 | 79 | 88 | 10 |
| F-100 | 2/52 | 17 | 41 | 58 | 29 |
| F-105 | 9/52 | 4 | 103 | 107 | 4 |
| C-130 | 9/52 | 20 | 77 | 97 | 21 |
| F-104 | 7/54 | 18 | 53 | 71 | 25 |
| F-4 | 5/55 | 7 | 89 | 96 | 7 |
| A-6 | 12/57 | 7 | 109 | 116 | 6 |
| F-111 | 12/62 | 34 | 84 | 118 | 29 |
| F-14 | 2/69 | 15 | 89 | 104 | 14 |
| F-15 | 12/69 | 56 | 91 | 147 | 38 |
| A-10 | 1/73 | 37 | 76 | 113 | 32 |
| F-16 | 1/75 | 40 | 72 | 112 | 36 |

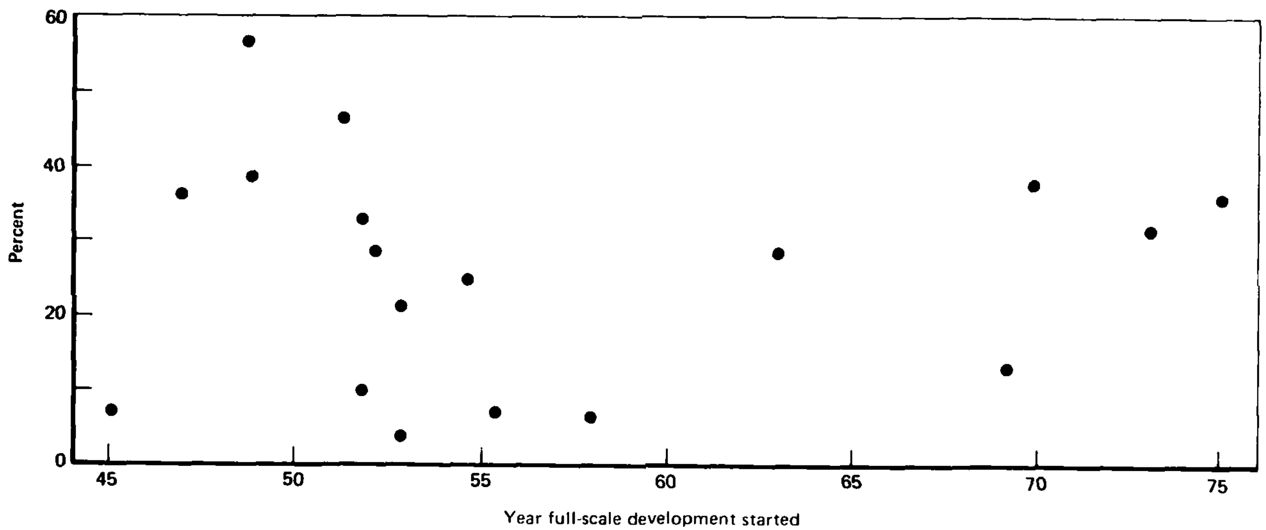


Fig. 11—Phase I duration, percent of total acquisition time

# IV. SUMMARY OBSERVATIONS

A major objective of this analysis was to determine if there were any patterns or trends in acquisition intervals over the past few decades. An examination of the data presented in the previous two sections reveals one strong and consistent pattern: a wide variability from system to system within any one time period. Despite that variability, some conclusions regarding long-term trends in interval duration can be drawn from the data.

## INTERVAL TRENDS

A summary of statistical results is shown in Table 9. It can be seen that with the exception of time to first flight, all entries show a positive slope (interval increasing over time) of several months per decade. A few of the data samples yielded results of apparently strong statistical significance, while others were less robust.[22] Cumulatively, these data suggest that the time required to develop an aircraft has been increasing over the past three decades. The growth has been most pronounced in the typical duration of Phase I (from Milestone I to Milestone II). Starting from an average of just over two years during the late 1940s and the 1950s, that interval has increased to an average of between three and four years today. Preliminary experience suggests that a Phase Zero duration of one to two years might be added before Phase I, thus causing the total decision time (leading up to Milestone II) to have at least doubled during the past three decades. However, effects of Phase Zero must be considered as highly speculative because of inadequate experience as yet.

Changes in typical interval duration have been less pronounced in the phases immediately after the start of full-scale development. In fact, there is no evidence that the time required for the initial engineering development of the system has changed significantly during the past three decades. This is rather impressive, considering that aircraft of recent vintage tend to be much more complex than those of earlier times.

Although there is some slight evidence that the test phase (between first flight and first operational delivery) has been lengthening somewhat, the statistical support for such a trend is very weak and is certainly inadequate by itself to justify any change in policy. This finding is particularly significant because of recent complaints that "excessive" testing has unduly delayed the operational availability of systems.

Finally, a clear change has occurred in the production phase of aircraft systems, where average production rate has been steadily decreasing over time. The central

[22]Changing one or two data points can make large differences in the statistical results, both in the slope of the trend and in the level of statistical confidence indicated. Thus even the trends that appear to have strong statistical support must still be treated with some skepticism.

Table 9

INTERVAL CHANGE TRENDS OVER THREE DECADES

| Interval | Sample | Change Rate (months/decade) | | Significance Probability (percent) | |
|---|---|---|---|---|---|
| DSARC I to II | Fighter/Attack Aircraft | 10 | | 1 | |
| | All Aircraft in Sample | 7 | | 9 | |
| | Aircraft + Missiles | 6 | | 3 | |
| | Complete Sample | 4 | | 16 | |
| Development start to first flight | Fighter/Attack Aircraft | -0.6 | | 77 | |
| | All Aircraft in Sample | 0.6 | | 83 | |
| | | (a) | (b) | (a) | (b) |
| Development start to first operational delivery | Fighter/Attack Aircraft | 7 | 5 | 10 | 15 |
| | All Aircraft in Sample | 4 | 5 | 34 | 15 |
| Development start to 200th delivery | Fighter/Attack Aircraft | 9 | 12 | 20 | 4 |
| | All Aircraft in Sample | 7 | 12 | 27 | 2 |
| Time to produce 200 units | Fighter/Attack Aircraft | 5 | | 13 | |
| | All Aircraft in Sample | 6 | | 8 | |

[a]Based on interval measured from earliest development start (Figs. 6 and 8).

[b]Based on interval measured from beginning of full-scale development (Figs. 7 and 9).

phase of the aircraft acquisition cycle has apparently not changed and the early and late phases have been lengthening.

## APPROACHES TO SHORTER ACQUISITION INTERVALS

A second objective of the study was to understand why any changes in acquisition intervals have occurred and (if possible) to suggest ways of reducing the typical interval duration. The variability within any one time period is large compared with any changes between time periods, suggesting that many factors other than administrative procedures are responsible for interval duration. However, it is possible to identify a few specific causes of the observed lengthening of average acquisition intervals. For this discussion it seems useful to first examine the later phases of acquisition, where the causes are obvious, and then to examine the more difficult aspects of the pre-DSARC II intervals.

### Production Phase

There is little question that the steady trend toward lower production rates for aircraft systems has been strongly influenced by the corresponding and well-known trend toward ever-increasing costs of production and operations. Higher production rates could easily be achieved if additional resources could be made available.

### Development Phase

The transition from development to production has been the subject of considerable discussion and analysis for some time, and the current impression of DoD and industry officials seems to be that the idea of "fly before you buy" had been overemphasized. However, our analysis provides scant support for the notion that testing time has been increasing to any significant extent. Furthermore, recent experience with the early service years of new weapon systems provides little evidence that the systems have been excessively refined before being put into production. In fact, assuming that some modest increase has occurred recently in the amount of time spent testing before high rate production, probably (although proof is lacking) at least some of the extra time is recaptured later through the more rapid maturation of recent systems. For example, the Hound Dog missile moved very rapidly through full-scale development and into production, but that fact alone tells a misleading story. The early missiles delivered to the using command were largely unworkable and would probably have been worthless in combat: The first fully successful flight test occurred *after* delivery of the last item (#161) in the first production lot. Such performance would be unlikely under the present management and review system, and not many would argue that the Hound Dog missile development was a model to be emulated. Whether too much pre-production testing is now being required is a question this study cannot address in detail, but the evidence collected here is certainly not sufficient to support any suggestions for change in the present policy.

### Requirement Formulation and Concept Validation Phase

Because little or no change has occurred in the engineering development time, we can turn our attention to the phase where an increase has apparently occurred —the requirements formulation and concept validation phase leading up to the beginning of full-scale engineering development. Here several different forces appear to be at work. For example, the urgency associated with a system development varies widely from one system to another and it is not inconceivable that long-term changes in national attitudes toward military expenditures could cause some of the observed variations in acquisition intervals. Furthermore, the decisions being made today during Phases Zero and I are of a somewhat different nature than was the case 20 years ago, in part because fewer new systems are being started every year. Figure 12 illustrates this trend as applied to fighter aircraft for the USAF. Other contributing factors may be the increasing difficulty of canceling programs

once they are underway, and the trend that makes each system cost more than its predecessor. Those factors are well known and must surely increase the time spent (before FSD begins) on debating the need and deciding on a development approach to a new program.

Increases in the duration of concept formulation and validation phases (at least of the size noted here) should not automatically be viewed as undesirable. For example, projects undertaken in the 1950s and 1960s exhibited fairly large cost growth, schedule slip, and performance shortfalls. It seems reasonable to expect that some of the increased acquisition time suggested by this analysis has contributed to the observed improvements in our ability to produce systems that come closer to predicted cost, schedule, and performance.[23] Furthermore, delays in the decision phase may have little effect on how "modern" a system is when delivered to the troops. Technology is continually changing, and designs are updated and refined throughout that phase, so that the quality of the product should be improving as time goes by. It is incontrovertible that decision delays will cause a slip in IOC, but if a delay occurs the system may be able to take advantage of new knowledge and be a more effective weapon when it is fielded.

There are several possible approaches to shortening the pre-Milestone II decision time. If the current directives are to be strictly observed, with MENS approval required before Phase Zero, then opportunities lie mainly in the area of streamlining budget procedures. Gaps of a year or more could occur because the necessary study funds were not budgeted before MENS approval, thus requiring another budget cycle before funds can be made available. To cope with this problem it may be appropriate to establish a "revolving fund." Once a MENS is approved, work could promptly start on the ensuing studies using money from the fund, and then later when the regular project appropriations have been provided by Congress, the "advanced" money could be repaid to the fund. Such a procedure would probably require the establishment of a specific budget line item for the revolving fund. Otherwise, the process would require no change in policy or procedure and could save over a year in some cases.

A more functional approach to reducing front-end decision time would be to administer the process with more flexibility than is suggested by the regulations and directives. As noted earlier, there is a wide variation among projects in terms of perceived urgency of operational need and in the degree of consensus that exists regarding the major issues surrounding the project. Under some conditions it would seem appropriate to permit the Services to proceed with Phase Zero studies on the basis of a draft MENS, and require final MENS approval only as a necessary condition for a DSARC I (or in some cases even DSARC II) review.

This suggestion does not imply a reversion to the days when programs were started with inadequate attention to long range consequences and were difficult to cancel after they accumulated momentum and broad political support. Although a small step back from the present formal policy, such a measure seems necessary if decision times are to be significantly reduced. Furthermore, the approach suggested here leaves intact many opportunities for control that did not exist during the 1950s and 1960s, and it in no way contravenes the letter or the spirit of OMB

[23]See E. Dews et al., *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s*, The Rand Corporation, R-2516-DR&E, October 1979.

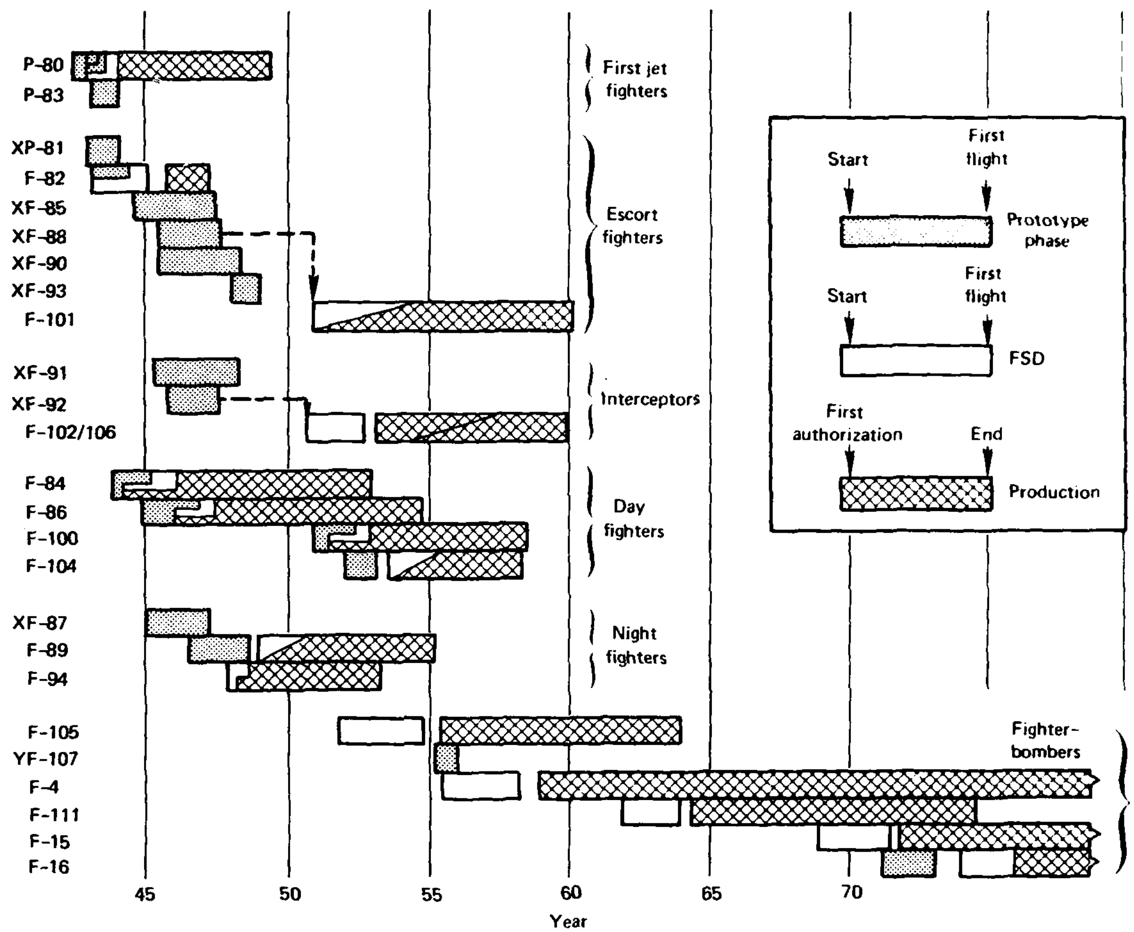


Fig. 12—Fighter aircraft development history

circular A-109. By having the Service submit a draft MENS before starting Phase Zero studies, the OSD would insure itself of being fully informed and would still have an early opportunity to review both the need for the system and the recommended approach to satisfying that need. Surely it should not be too difficult to cancel, or significantly redirect, a program at that stage.

Such a procedure would almost certainly reduce the front-end decision time (compared with the time required under strict observance of the directives), but it would also have three other consequences worth noting:

1. The "critical decision point," where the intention to complete the full acquisition program is affirmed, would be pushed downstream to at least Milestone I, and possibly into Phase I, but in no case later than Milestone II. Such a change should be advantageous because more information (Phase Zero study results) would be available to those responsible for approving the MENS. The approval of a mission need in the absence of some assurance that the desired capability can actually be achieved is a meaningless exercise. Therefore, results of Phase Zero studies cannot but help in MENS review.
2. It would sometimes be necessary to cancel a project after Phase Zero studies had started, but before Milestone II. This would have only a small fiscal consequence because in the vast majority of cases Phase Zero and Phase I expenditures are a very modest fraction of total acquisition cost. However, some institutional stress is obviously introduced by any such cancellation.
3. A somewhat larger menu of mission elements would be addressed early in the planning phase, and additional options would be presented to the decisionmakers at a point later in the acquisition cycle. Considering the rate at which perceptions of military needs and priorities change, such added flexibility is well worth the possible cost of having to cancel an occasional program during its study phase.

The approaches outlined above certainly would entail some costs of one kind or another, and some may prove to be impractical. However, if no action is taken along the general lines suggested here, there seems to be no feasible way of reducing the duration of Phase Zero or Phase I and still providing for a thorough and responsible review of the proposed weapon systems.

# Appendix A

## A COMPENDIUM OF AIRCRAFT PROGRAM MILESTONES

CONTENTS



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# F3D DOUGLAS SKYNIGHT

- o First jet-propelled night fighter(a)
- o Deployed to Korea soon after the war there began, Skynights were responsible for the destruction of more enemy aircraft than any other type of aircraft flown by the Navy or Marines
- o Two-seat, jet-propelled, carrier-based, all-weather fighter

| Date | Event | Source |
|---|---|---|
| 3 April 1946 | Contract issued to Douglas for design and construction of three prototypes | 18; 29 |
| 23 March 1948 | First F3D prototype flight | 18; 29 |
| June 1948 (Full-scale development (FSD) start) | 28 F3D-1s purchased | 29, p. 415; 18 |
| 13 February 1950 | First production F3D-1 flown | 18, p. 182 |
| May 1950 | First of 28 F3Ds completed | 29 |
| August 1950 | First F3D-1 accepted | |
| December 1950(b) | First F3Ds delivered to Night Composite Squadron VC-3 at Moffett Field | 43 |
| April 1953 | 200th delivery | |

(a) The designation for fighter aircraft was changed from "P" to "F" on 11 June 1948 by the newly created USAF. For consistency throughout this listing, the "F" designation will be used.

(b) 18 gives approximate delivery date as February 1951.

## F-84 REPUBLIC THUNDERJET

- o Last of the subsonic fighter-bombers to see operational service with USAF
- o Flight-refuelling techniques for fighters were developed for this aircraft
- o First single-seat fighter bomber capable of carrying a tactical nuclear weapon
- o Developed to test the GE-TG 180 jet engine

| Date | Event | Source |
|---|---|---|
| 11 September 1944 | GOR issued | 10, p. 23 |
| October 1944 | First design initiated | |
| 11 November 1944(a) (Prototype start) | First development contract for 3 fighter airplanes for static test, flight article mock-up | 10, p. 23 |
| 4 January 1945(b) (FSD start) | AAF ordered 100 service test and production F-84s | 10, p. 24 |
| November 1945(c) | First prototype completed | 47 |
| 28 February 1946(d) | First flight XF-84 at Muroc AFB, California | 10, p. 25; 9 |
| August 1946 | Second XF-84 prototype completed | 9, p. 214 |
| 6 September 1946(e) | Second XF-84 sets speed record | 9, p. 214; 20 |
| January 1947 | First flight of YF-84 | |
| February 1947(f) | AF takes delivery of 15 YF-84As | 10, p. 26 |
| June 1947 | First production deliveries of F-84B | 17, p. 463 |
| December 1947 | Enters operational service | 10, p. 26 |
| April 1948 | 200th delivery | 10, p. 27 |
| November 1950 | TAC begins development of the F-84 to carry nuclear bombs for tactical warfare | 17, p. 464 |
| Spring 1952 | F-84G--first single-seat fighter bomber with atomic capability | 17, p. 464 |
| June 1953 | Last delivery | 137, p. 36 |

(a) 9, p. 214 confirms the order for three but dates it as early 1945.
(b) 47 gives December 1944 as date of quantity order.
(c) 9, p. 214 gives completion date as December 1945.
(d) 47 dates first flight one day earlier--26 February.
(e) 10, p. 25 claims second prototype flew in August and established speed record in September.
(f) 29, p. 257 gives April 1947 as first acceptance.

## F-86 NORTH AMERICAN SABRE

- o USAF's first swept-wing fighter
- o First American fighter to pass Mach 1
- o Significantly increased our air power in Korean War
- o Design influenced by German scientific data on swept-wing

| Date | Event | Source |
|---|---|---|
| 1944 | North American submits several straight-wing fighter configurations to the AF | 114, p. 4 |
| 11 April 1945(a) | GOR issued | |
| 18 May 1945(b) (Prototype start) | Contract for 3 XF-86 prototypes (straight-wing design) | 114;19 |
| June 1945 | USAF approves first version mock-up | 114 |
| 1 November 1945 | AF endorses North American's proposal to scrap the straight-wing design in favor swept-wing | 10; 114; 9, p. 225 |
| 28 February 1946 | AF approves swept-wing mock-up | 114 |
| August 1946 | North American releases their XF-86 engineering drawings to the manufacturing division | 114 |
| 20 December 1946 (FSD start) | Production go-ahead for 33 F-86s | 10, p. 53; 114 |
| 8 August 1947 | First of 3 XF-86s completed and turned over for flight tests | 114 |
| 1 October 1947 | First prototype flight, XF-86 | 9, p. 225; 10; 114; 20 |
| 25 April 1948(c) | F-86, equipped with Allison TG-180 (J-35) engine, becomes first American fighter to exceed Mach 1 | 22, p 258; 46; 114 |
| 20 May 1948(d) | First flight production aircraft | 10, p. 54; 20, p. 258 |
| 28 May 1948(e) | First production acceptance | 137, p. 38; |
| February 1949 | Enters operational service | 10, p. 54 |
| October 1949 | 200th delivery | |
| 8 November 1950 | Sabres ordered into combat in Korea | 9, p. 225 |
| 17 December 1950 | F-86 flew first mission in Korea | 10, p. 54 |
| October 1955 | Last delivery | 137, p. 38 |

(a) 10, p. 53 gives GOR date as May.

(b) 10, p. 53 claims only 2 prototypes were ordered. 8 notes that 3 Navy prototypes, ordered 1 January 1945, were built and flown as conventional straight wing aircraft.

(c) 9, p. 225 gives April 26.

(d) 17 states May 18 as first production flight.

(e) 8, p. 42 gives December 1948 as the date of F-86A service delivery.

F-89 NORTHROP SCORPION

- o All-weather ground attack fighter
- o Designed to succeed P-61 Black Widow

| Date | Event | Source |
|---|---|---|
| August 1945(a) | Advanced Development Objective (ADO) | |
| 28 August 1945 | AF asks for design proposals | 10 |
| 23 November 1945 | GOR/SOR issued | |
| December 1945 | Northrop submits their proposal to AF for all-weather ground attack fighter | 9, p. 238; 29, p. 264; 17, p. 441 |
| March 1946 | Six aircraft manufacturers enter competition | 10, p. 83 |
| 13 June 1946(b) (Prototype start) | Initial procurement--Northrop receives $4 million letter contract for two experimental F-89s | 10, p. 84 |
| September 1946 | Mock-up inspection | 29, p. 264 |
| 18 December 1946(c) | Contract for two experimental planes finalized | 29, p. 264; 17, p. 441; 19 |
| 16 August 1948 | First flight of prototypes with J-35-A-9s | 20; 10, p. 84; 5, p. 207; 29, p. 264 |
| 14 October 1948 (FSD start) | Go-ahead decision | 10, p. 84 |
| 14 July 1949 | Approval of F-89A contract; production orders placed | 17, p. 442 |
| 27 June 1950 | YF-89A (second prototype modified with new engines, J-35-A-21s with afterburners) makes first flight | 10, p. 86 |
| 28 September 1950(d) | First acceptance of production aircraft | 10 |
| Mid-1951 | F-89A and B began to reach ADC squadrons | 17, p. 443 |
| January 1954 | 200th delivery | |
| September 1956 | Last delivery | 137, p. 40 |

(a) 10 gives "Spring" as ADO date. 137, p. 40 gives August 1945 as requirement date.

(b) 17, p. 441 claims that Northrop's design was accepted and a development contract was issued on 3 May 1946; 29, p. 264 confirms May.

(c) 10 disagrees; claims December marks second mock-up and Northrop is authorized to proceed with construction of first airplane.

(d) 17, p. 442 and 29, p. 265 give July 1950 as the date for first F-89A delivery.

## F-94 LOCKHEED STARFIRE

- o First jet-powered, all-weather fighter to enter USAF service
- o Two-place interceptor version of the F-80 "Shooting Star"
- o Designed for high-altitude, radar-controlled interception of enemy aircraft

| Date | Event | Source |
|---|---|---|
| 8 October 1948 | GOR issued | 10, p. 101 |
| 14 October 1948 (FSD start) | Go-ahead decision on F-80 two-place modification; becomes F-94 in 1959 | 10, p. 101 |
| January 1949(a) | Letter contract with Lockheed | 10, p. 101 |
| | Initial procurement | |
| 16 April 1949(b) | First flight of XTF-80C (radar equipped TF-80C) | 10, p. 101 |
| 1 July 1949(c) | First flight of YF-94 | 10, p. 101; 17, p. 340 |
| December 1949(d) | AF accepts first F-94A | 10, p. 103 29, p. 265 |
| August 1950 | IOC | 10, p. 102 |
| April 1951 | Enters operational service with ADC's 61st Fighter Interceptor Squadron at Selfridge AFB | 10, p. 104 |
| | 200th delivery | |

(a) This L/C was replaced a few months later by a definitive contract (AF-1849) covering 150 F-94s (later reduced to 109)--10, p. 101.

(b) 29 says this was the first flight of YF-94.

(c) Two T-33A trainers, improved and redesignated TF-80Cs, were modified for the interceptor role by adding radar noses and rear-fuselage afterburners. These aircraft were used by Lockheed as F-94 prototypes to speed development--10, p. 101.

(d) There is little agreement on "delivery" and "enters operational service" dates. 10, p. 102 says that the F-94A enters operational service and begins to reach air defense units in May 1950. 9, p. 253, and 17 claim that deliveries begin to the 319th All Weather Fighter Squadron in June 1950. 66, p. 1152 gives 16 June 1950, as the date when the Air Force accepts delivery of the first two F-94s.

# F4D DOUGLAS SKYRAY

- o Bat-winged interceptor designed for catapult operation from carriers
- o Designed for rapid rate of climb and high speeds

| Date | Event | Source |
|---|---|---|
| 1947 | U.S. Navy proposal for a short-range, carrier-based interceptor fighter | 18, p. 184 |
| 1948 | Basic design work begins | 119, p. 492; 126, p. 251 |
| 16 December 1948 (Prototype start) | Two prototypes ordered | 18; 29 |
| 23 January 1951 (Prototype start) | First XF4D-1 prototype flown with XJ40-WE-6 and XJ40-WE-8 | 5, p. 167 29; 18; 119; 23, p. 237 |
| March 1953 | Switch in engine--production F4D-1s to have J57-P-2 | 18 |
| 5 June 1954 | First production flight of F4D-1 | 18; 29; 5, p. 167 |
| May 1955(a) | First delivery | |
| August 1957 | 200th delivery | |
| 1958 | Production stopped--420 F4D-1s had been built | 34, p. 166 |
| September 1962 | Redesignated F-6A | 18 |

(a) 34, p. 166 claims that deliveries began in 1954 but that the first operational squadron was not formed until 1956. 18 gives 16 April 1956 as the date for first delivery to a Navy unit and 29 confirms April as the correct month.

F-100 NORTH AMERICAN SUPER SABRE

- Evolved from the F-86 Sabre
- Originally designated by North American as "Sabre 45" because of the aircraft's 45 degrees of wing sweepback
- North American spent one year on its own on development before working with the Air Force

| Date | Event | Source |
|---|---|---|
| February 1949 | F-100 begins to take shape as F-86 goes into production | 130 |
| September 1950 | ADO issued | 10, p. 113 |
| January 1951(a) | GOR/SOR issued | |
| 15 January 1951 | Unsolicited proposal--North American submits Sabre 45 design for consideration as supersonic day fighter | 10, p. 113; 171 |
| October 1951 (Prototype start) | AF gives go ahead on Sabre 45 | 10, p. 113 |
| 30 November 1951 | Sabre 45 renamed F-100 | 10, p. 113 |
| 3 January 1952(b) | Development contract--two prototypes ordered | 10, p. 113 |
| 11 February 1952 (FSD start) | First contract for production 23 F-100As | 10, p. 113 |
| 24 April 1953 | First prototype completed | 171; 96 |
| 25 May 1953 | First flight of prototype (YF-100A) | 10; 23; 80; 83, p. 41 |
| 28 September 1953 | First production F-100A completed | 171; 96 |
| October 1953 | First production acceptance | |
| 14 October 1953 | First flight, second prototype | 10 |
| 20 October 1953 | First production F-100 rolls out | 35, p. 15; 83 |
| 25 October 1953(c) | F-100A sets an official world speed record of 755.149 mph | 45 |
| 29 October 1953 | First flight of production F-100A | 10, p. 114; 171 |
| 29 September 1954(d) | F-100A becomes operational with Tactical Air Force's 479th Wing | 109; 62 |
| 12 October 1954 | F-100A accident--kills pilot George Welch | 126, p. 251 |
| 11 November 1954 | F-100s grounded | |
| February 1955 | AF lifts grounding | 35, p. 15 |
| July 1955 | 200th delivery | |
| September 1955 | IOC | 10, p. 115 |
| October 1959 | Final delivery | 8, p. 90 |

(a) 10 dates GOR as 27 August 1951.

(b) 9 and 29 claim that on 1 November 1951, the AF authorized two YF-100s and 100 F-100As. No mention of this date or purchase of 100 aircraft is found elsewhere.

(c) 23 and 96 note that speed record was on 29 October.

(d) 10, p. 115 dates this as 27 September.

# F-101 MCDONNELL VOODOO

- Derivative of McDonnell F-88
- Designed to escort very high-flying, long-range bombers
- Twin-jet supersonic fighter

| Date | Event | Source |
|---|---|---|
| August 1945 | Engineering Division at Wright Field issues industry-wide, preliminary design competition characteristics; thirteen companies respond with 20 design proposals | |
| May 1946 | McDonnell receives a Phase I development contract covering work through mock-up of the XF-88 | |
| June 1946 | Detail design work begins | 17, p. 363 |
| August 1946 | Mock-up inspection | |
| June 1948 | Plane completed and ready for engineering inspection | |
| September 1948(a) | First flight of XF-88A | |
| March 1949 | Plane ready for shipment to Edwards; Phase I flight testing completed | |
| April 1949 | Phase II test program completed | |
| August 1950 | Experimental contract terminated because of cutback in funds | 25, p. 347 |
| January 1951 | AF decision to seek new escort fighter design | 10, p. 135 |
| 6 February 1951 | GOR issued | 10, p. 136 |
| May 1951 | McDonnell F-88 chosen in AF competition | 10, p. 136 |
| October 1951 (FSD start) | Production go-ahead; FY52 funds released to get F-88 into production; speed-up because of Korean War | 10, p. 136 |
| 30 November 1951 | F-88 renamed F-101 Voodoo | 10 |
| 15 January 1952(b) | Development contract--77 planes (no prototypes) ordered | |
| | McDonnell accepts initial L/C offered by AF | 10, p. 137 |
| May 1953 | Construction of the first F-101 begun | 9, p. 269 |
| 29 September 1954(c) | First flight F-101A | 17, p. 363; 25, p. 347; 5, p. 193; |
| 10 May 1956 | First flight YRF-101A | 17, p. 363 |
| 27 March 1957 | First F-101B flown | 10, p. 151 |
| 2 May 1957 | First delivery of F-101A; enters operational service with TAC | 17, p. 363; 5, p. 193; 10, p. 140; 25, p. 347 |

F-101 MCDONNELL VOODOO--continued

| Date | Event | Source |
|---|---|---|
| May 1958 | 200th delivery | |
| March 1961 | Final delivery | 8, p. 25 |

(a) 10 disagrees; dates first flight 20 October 1948, as does 8.

(b) 96 says McDonnell received a sizable production contract in January 1952 with appropriations totaling $20 million. Source 29 confirms that the January L/C was for 29 F-101As, for design and development through mock-up. 10 states that the contract was not finalized and signed by the AF until 11 June. 29 reports that an order was placed for the 77 aircraft after the 29 September 1954 flight.

(c) 105 dates first prototype flight as October; 17, p. 363 gives more specifically 20 October 1948.

## F-102 CONVAIR DELTA DAGGER

- First delta-wing design accepted for operational use by the Air Force
- First use of the Weapon System Concept
- Grew out of Convair's experimental XF-92A, first true delta-wing powered aircraft to fly in the U.S.
- First fighter to dispense with gun armament completely in favor of guided missiles and unguided rockets

| Date | Event | Source |
|---|---|---|
| August 1945 | Tentative interceptor requirements | |
| September 1948 | XF-92 first flight | |
| 13 January 1949 | ADO issued | 10, p. 259 |
| 18 June 1950 | Request for proposals for Project MX-1554 (operational date of 1954 | 10, p. 159 |
| 18 August 1950 | GOR issued | |
| 31 August 1950 | First development contract | |
| January 1951 | Bidding closed--six contractors had submitted nine proposals | 10, p. 160 |
| 2 July 1951(a) | AF names three winners for Phase I development: Convair, Republic, Lockheed | 10, p. 160 |
| 11 September 1951 (FSD start) | Convair awarded L/C | 10, p. 160 |
| 24 November 1951 | AF decides to expedite the 1954 Interceptor program--will follow Cook Craigie plan for early tooling, limited production at first, elimination of faults by test flights, and accelerated production thereafter | 10, p. 161 |
| October 1952(b) | Production order to Convair | 127 |
| 18 November 1952 | F-102A mock-up inspection | 10, p. 162 |
| 12 June 1953 | Definitive contract for production; supersedes previous L/Cs | 10, p. 163 |
| 24 October 1953 | YF-102 makes first flight | 5, p. 154; 17, p. 169; 10, p. 163; 25, p. 287 |
| 2 November 1953 | The first YF-102 is wrecked in emergency landing | 10, p. 164 |
| 11 January 1954 | First flight of second YF-102 | 17, p. 169; 25, p. 287 |
| March 1954 | AF gives Convair second production contract | 10, p. 164 |
| 4 November 1954 | New GOR--Convair forced to meet new altitude and combat radius requirements | 10, p. 164 |
| 19 December 1954(c) | First flight of production configuration, YF-102A | 10, p. 165 |
| June 1955 | F-102A production models begin delivery | 5, p. 154; |
| 24 June 1955 | First flight production F-102A | 10, p. 165; 17, p. 169 |

F-102 CONVAIR DELTA DAGGER--continued

| Date | Event | Source |
|---|---|---|
| June 1956(d) | First squadron becomes operational | 29; 5, p. 154 |
| January 1957 | 200th delivery | |

(a) 10 states that soon after the three winners were announced, the AF decided against letting three manufacturers work through Phase I. Lockheed was canceled entirely and the letter contract of September declared Convair the winner--although the Republic XF-103 development was still authorized.
(b) 10 states that a definitive contract for production was not awarded until 12 June 1953.
(c) 24 dates YF-102A flight at 20 December as does 17, p. 169; 5, p. 154; and 8, p. 117.
(d) 10 says the F-102A enters service with the Air Defense Command's 327th FIS at George AFB in April 1956.

F-104 LOCKHEED STARFIGHTER

- o First operational interceptor capable of sustained speeds above Mach 2
- o Developed from Lockheed F-90
- o First aircraft in history to hold world records for both absolute speed and altitude (1,404.19 mph and 91,249 ft) simultaneously

| Date | Event | Source |
|---|---|---|
| November 1952 | Lockheeds submits unsolicited proposal for new air superiority fighter | 9, p. 278; 10, p. 175; 17, p. 343 |
| 12 December 1952 | GOR for lightweight air superiority day fighter to replace TAC's F-100s in 1956 | 10, p. 175 |
| January 1953 | Competitive bidding by Republic, North American, and Lockheed | 10, p. 175 |
| 11 March 1953 (Prototype start) | Letter contract given to Lockheed for two XF-104s and one year of flight testing | 9, p. 278; 10, p. 176; 17, p. 343 |
| 30 April 1953 | Mock-up inspection | 10, p. 176 |
| November 1953(a) | Definitive contract | |
| 7 February 1954(b) | First flight XF-104 | 17; 19; 5; 27; 29; 8 |
| July 1954 (FSD start) | AF decides to purchase 17 aircraft for development tests | 10, p. 176 |
| October 1954 | First production contract for 17 F-104s--initial procurement | 10, p. 176 |
| October 1955 | New letter contract to Lockheed exceeds $100,000,000 | 38, p. 12 |
| 17 February 1956 | First flight production aircraft F-104A | 10, p. 177; 5, p. 187; 26, p. 372 |
| January 1957 | First production acceptance | |
| 26 January 1958 | Becomes operational with the Air Defense Command | 10, p. 178; 9, p. 278; 29; 5, p. 187; 17, p. 343; 26, p. 372 |
| December 1958 | 200th delivery | |
| 1964 | Final delivery | 8 |

(a) This date was not confirmed by any other source.
(b) 10, p. 176 gives 28 February 1954.

# F-105 REPUBLIC THUNDERCHIEF

- Single-seat, single-engine aircraft, meant for a nuclear role but also having an air-to-air capability
- Designed from the start as a Tactical Air Force fighter-bomber to succeed the F-84F

| Date | Event | Source |
|---|---|---|
| 1951 | Design work begins | 26, p. 339 |
| March 1952 | Requirement issued | 137, p. 46 |
| April 1952 | Republic submits a proposal for their model AP-63 | 10, p. 191 |
| May 1952 | Air Staff, upon recommendation of the Aircraft & Weapon Board, endorses F-105 development | 10, p. 191 |
| September 1952(a) (FSD start) | Letter contract for 199 aircraft--first to be operationally ready by 1955 | 10, p. 191 |
| 10 September 1952 | GOR issued | |
| March 1953 | Letter contract reduced to 37 F-105s and nine RF-105s | 10, p. 191 |
| October 1953 | Mock-up inspection | 10, p. 191 |
| December 1953 | AF suspends procurement because of Republic's excessive delays | 10, p. 191 |
| February 1954 | Procurement reinstated but order reduced to 15 | 10, p. 191 |
| September 1954 | AF reduces order to three because of further delays | 10, p. 191 |
| October 1954 | AF restores order to six | 10, p. 191 |
| 1 December 1954 | Amended GOR 49 called for inflight refueling capability, a more complex fire control system, improved performance, installation of J-75 engine | 10, p. 192 |
| 22 October 1955 | First flight of YF-105A (with interim J-57 engine) | 26; 5, p. 213; 17, p. 469; 10, p. 192; 72, p. 7 |
| 28 January 1956 | Second YF-105A makes first flight | 10, p. 192 |
| March 1956 | AF releases $10 million of FY57 funds for the acquisition of 65 F-105Bs and 17 RF-105s | 10, p. 192 |
| 26 May 1956(b) | First YF-105B makes first flight (first model with J-75 engine); damaged on landing--flight test program delayed | 10, p. 192 |
| 24 May 1957 | First F-105B flown | 17, p. 470 |
| 22 November 1957 | Further revision to GOR 49 | 10, p. 193 |
| 27 May 1958 | First acceptance of production aircraft, F-105B | 5, p. 213; 17, p. 470; 10, p. 193; 113, p. 8; 76, p. 31 |
| August 1958 | Enters operational service | 10, p. 193 |

F-105 REPUBLIC THUNDERCHIEF--continued

| Date | Event | Source |
|---|---|---|
| January 1959(c) | F-105 declared operational | 17, p. 469 |
| April 1961 | 200th delivery | |
| 1965 | Final delivery | 8, p. 94 |

(a) Letter contract covers preproduced engineering, tooling design, fabrication, and material procurement.
(b) 26 gives 22 May 1956 as first F-105B flight.
(c) 10 disagrees; as late as March 1960, none of TAC's F-105s were operationally ready.

# F-106 CONVAIR DELTA DART

- o Grew out of Convair's delta wing XF-92
- o Developed during 1955 under the designation of F-102B
- o Originated as part of 1954 Ultimate Interceptor Program
- o All-weather jet interceptor

| Date | Event | Source |
|---|---|---|
| 13 January 1949 | ADO--1954 Ultimate Interceptor | 10, p. 207 |
| September 1951 | Convair's entry selected, design work started on F-102 | 10, p. 207 |
| 24 November 1951 | AF production decision, F-102A | 10, p. 207 |
| December 1951 | AF authorizes two step production F-102A and B with same airframe | 10, p. 207 |
| November 1955(a) (FSD start) | Convair awarded new production contracts: 562 F-102As and 17 F-102Bs (brings A total up to 749) | 10, p. 208 |
| 18 April 1956 | F-102B production contract finalized--17 F-102Bs earmarked for testing | 10, p. 208 |
| 17 June 1956 | F-102B re-designated F-106 | 10, p. 209 |
| 28 September 1956 | AF issues System Development Directive outlining requirements | 10, p. 209 |
| 26 December 1956 | First F-106A flight | 10, p. 209; 5, p. 155; 95, p. 6 |
| April 1957 | AF conditionally accepts several F-106s | 10, p. 210 |
| | F-106B ordered into parallel production with F-106A | 25, p. 286 |
| June 1957(b) | Quantity production begins | 9, p. 287 |
| 19 June 1957 | GOR--28 September 1956 requirements finalized | 10, p. 210 |
| 9 April 1958(c) | F-106B makes first flight | 17, p. 172; 10, p. 219; 25 |
| June 1958(d) | Initial delivery of production aircraft | |
| October 1959 | IOC | 10, p. 212 |
| April 1960 | 200th delivery | |

(a) First distinguishable event identified with the F-102B/F-106, although actual development work can be traced to early phases of F-102A program.
(b) 5 gives August.
(c) 5 gives April 19.
(d) First acceptance after initial development lot of 17 airplanes. Actual operational service was delayed until 1959. (10 says May; 8, 17, 29 and 25 say July.)

F4H MCDONNELL PHANTOM II

- Designed as a twin-engined replacement for the Navy's F3H all-weather fighter
- Originally designated AH-1

| Date | Event | Source |
|---|---|---|
| Mid-1953 | Specification for a new carrier-based aircraft is drawn up | 84, p. 213 |
| September 1953 | McDonnell presents Navy with unsolicited proposal | 29, p. 424 |
| 1954 | Construction of a full-scale mock-up of F3H-G with J65 engines | 84; 6, p.11 |
| 18 October 1954(a) | Letter of intent for design work only (no firm requirement) on AH-1 ground attack types with J-79 engines | 29; 27, p.341 |
| April 1955 | Six months work scrapped--new specification details necessitate a major re-design | 84; 6 |
| 26 May 1955(b) (FSD start) | Development authorized; redesignated as XF4H-1 missile fighter | 29; 27; 6 |
| July 1955 | Agreement reached on detail specification for F4H-1 | 6 |
| 27 May 1958 | First flight of XF4H-1 | 29; 27; 84 |
| December 1958(c) | McDonnell receives order for 375 F-4s from the U.S. Navy | 84 |
| December 1960(d) | First operational delivery | |
| 1962 | F4H-1 redesignated F-4A | 29 |
| March 1962 | First F-4 accepted by USAF | 34, p. 166 |
| October 1962(e) | 200th delivery | |
| 1978 | 5,000th Phantom rolled off assembly line--operated by 11 countries--served in Vietnam War with USAF, Navy, and Marine Corps | 84 |
| | Still in production in 1979 | 34 |

(a) 84 gives November 1954 as the date of the letter of intent.

(b) The complete system with avionics and missiles was included in prototypes.

(c) 8 claims that in December 1958 BuAer awarded a limited contract for 23 development Phantom IIs plus 24 production aircraft.

(d) Considerable confusion exists in the records on early deliveries. The initial production run of 23 aircraft (in lots of 7, 11, and 5) were clearly F-4A, with the last five incorporating the larger radar dish diameter. Some sources show the second batch of 24 to be F-4A, while other sources call those airplanes F-4B. Regardless of designation, all sources except 84 (including personal recollections of the McDonnell program manager) indicate that the lot starting with unit #24 were the first airplanes delivered to the Navy for operational use. Initial acceptance date of that 24th airplane is also a matter of some uncertainty. Factory records show the first item of that lot to be delivered in December 1960. 27 also gives December 1960 as the date that the first production Phantom II was delivered to a U.S. Navy Squadron, VF-101. However, 6, p. 26, gives February 1961 as date of delivery for inventory.

(e) This assumes that all F-4As were development items.

# F-111 GENERAL DYNAMICS

- o World's first variable-geometry aircraft designed as an operational plane
- o First tactical fighter designed from the start to meet the requirements of two major fighting services

| Date | Event | Source |
|---|---|---|
| 27 March 1958 | GOR issued | 10, p. 223 |
| 29 March 1959 | GOR canceled--AF feels vertical takeoff not yet possible | 10, p. 223 |
| 5 February 1960 | System Development Requirement 17 incorporated most of the original requirements except vertical take-off | 10, p. 223 |
| March 1960 | NASA reports feasibility of variable wing sweep | 1, p. 179 |
| April 1960 | ARDC/TAC joint agreement on development program | 1 |
| 14 July 1960 | SOR 183 issued | 161 |
| October 1960 | AF request for proposals prepared but deferred by Eisenhower | 10, p. 224; 3, p. 451 |
| February 1961 | McNamara says TFX should be developed to meet needs of AF and Navy | 1, p. 179 |
| 7 June 1961 | McNamara concludes TFX should fulfill Navy and AF requirments; directs AF to begin development | 1, p. 179; 155 |
| September 1961 | Official program go-ahead for joint Navy-AF program | |
| 29 September 1961(a) | New request for proposals | 10, p. 225 |
| December 1961 | TFX designated F-111A | 10, p. 225 |
| 19 January 1962(b) | Source Selection Board votes unanimously to recommend Boeing as winner of TFX contract | 1, p. 180 |
| 1 February 1962(c) | $1 million L/C to Boeing and General Dynamics for more design data | 155; 151 |
| 11 September 1962 | Boeing and General Dynamics submit their fourth and final proposals to the Source Selection Board | 1, p. 180 |
| 2 and 8 November 1962 | Source Selection Board and AF Council recommend Boeing | 1, p. 181 |
| 24 November 1962 | General Dynamics design selected | 29, p. 280; 9, p. 297; 1, p. 181; 17; 151 |
| 21 December 1962 (FSD start) | R&D letter contract issued to General Dynamics for 18 F-111As and five F-111Bs | 155; 161; 151 |
| 1 May 1964(d) | Definitized contract for 23 development aircraft | 10, p. 226 |
| 15 October 1964 | Roll-out of the first F-111A | 17 |
| 21 December 1964 | First prototype flight | 9, p. 297; 10, p. 226; 161; 26, p. 346 |

F-111 GENERAL DYNAMICS--continued

| Date | Event | Source |
|---|---|---|
| 6 January 1965 | Second prototype flight | 17 |
| 12 April 1965 | Production L/C to General Dynamics | 29, p. 281; 10, p. 227; 19; 161; 17 |
| 18 May 1965 | First F-111B flies | 19 |
| July 1966 | An F-111 reached maximum design speed of Mach 2.5 for the first time | |
| 12 February 1967 | First flight F-111A production aircraft | 10, p. 278; 153, p. xvi |
| April 1967(e) | First production acceptance | |
| 16 October 1967 | First delivery of F-111A production aircraft to operational wing | 37, p. 119; 17, p. 296 10, p. 229; 9, p. 300; 29, p. 281 |
| 25 March 1968 | F-111As enter combat over Vietnam | 29, p. 281 |
| 28 April 1968 | IOC | 10, p. 229; 161 |
| April 1968(f) | Cancellation of F-111B | 18, p. 252 |
| December 1969 | 200th delivery | |

(a) 1, p. 180, dates RFP as 1 October.
(b) The Source Selection Board and AF Council recommend Boeing three more times in 1962: 14 and 24 May, 20 and 21 June, and 2 and 8 November, respectively--1, pp. 180-181.
(c) 17, p. 295, report that General Dynamics and Boeing are selected as finalists in January 1962.
(d) 155 says that the contract is approved May 22 and distributed on May 27.
(e) 7 claims first service delivery occurs in June 1967. 37, p. 119, gives July 1967 as the initial delivery date of an F-111A to a training unit.
(f) Secretary of the AF Harold Brown stopped work on the F-111B after the House Armed Services Committee disapproved an appropriation for further development and procurement of the Navy model.

## F-14 GRUMMAN TOMCAT

- o All-weather, carrier-based, weapon system capable of performing air-to-air combat and air-to-surface attack missions
- o Twin-engine, two-place variable sweep wing, supersonic fighter

| Date | Event | Source |
|---|---|---|
| September 1966 | Preliminary studies | 170 |
| October 1967 | Grumman submits unsolicited proposal to Navy | 135 |
| 30 November 1967 | Navy Fighter Study initiated to determine Navy tactical fighter requirements and the feasibility of the Grumman design | 139, p. 10 |
| March 1968 | Navy Fighter Study results published recommending Navy proceed with contract definition | |
| April 1968 | F-111B cancelled; however, use of avionics and engines that had been developed under the F-111B program enabled development and production to proceed rapidly | 18, p. 252; 145, pp. 6-7 |
| 21 June 1968(a) | Requests for proposals to five manufacturers | 159; 26, p. 355 |
| 17 July 1968(b) | USN awards contracts to five manufacturers to initiate contract definition phase of VFX program--$3 million each to five contractors | 159; 26, p.355 |
| 1 October 1968 | Due date for proposals | 26 |
| 17 December 1968 | Source Selection authority announces Grumman and McDonnell Douglas as finalists--proposals to be modified and resubmitted in January 1969 | 26 |
| 15 January 1969 | Grumman Model 303 announced winner | 18, p. 252<br>9, p. 341 |
| 3 February 1969(c) (FSD start) | Grumman awarded engineering development contract for six F-14As--contract signed | 159 |
| May 1969 | Airframe mock-up | 159 |
| 21 December 1970(d) | First flight of development aircraft | 9, p. 341; 18, p. 252; 159 |
| 30 December 1970 | Second flight--hydraulic system fails and plane is lost, causing testing delays | 159; 18, p. 252 |
| 24 May 1971 | Flight testing resumes with second plane | 9, p. 341<br>18, p. 252 |
| May 1972(e) | Production deliveries begin | 135; 16 |
| 12 October 1972(f) | F-14A delivered to Fleet | 9, p. 341; 27, p. 308; 8 |
| July 1976 | 200th delivery | |

(a) 135 dates RFP release as December 1967.
(b) 170 gives June as CDP contract award date.
(c) 9, p. 341 says that six planes were ordered for the development program and six more as preproduction F-14As.
(d) 159 notes flight occurred one month ahead of schedule.
(e) 144 dates first delivery of F-14A one month later, in June. 18 gives "late 1972."
(f) Squadron delivery occurs in early 1973--14, p. 171. 135 gives July 1974 as F-14A fleet deployment date.

# F-15 MCDONNELL DOUGLAS EAGLE

- o Originally named F-X
- o Tactical fighter aircraft designed to maintain air superiority through air-to-air combat with nonnuclear weapons

| Date | Event | Source |
|---|---|---|
| April 1965 | Department of the AF directed AFSC to initiate actions to develop and acquire a new tactical support aircraft weapon system | 151, p. 3 |
| April 1966 | F-X study awarded to three firms | 170 |
| 12 August 1966 | F-X System Program Office established | |
| September 1966 | A Preliminary F-X Concept Formulation Package presented to the ASD Council | |
| June 1967 | Concept Formulation Package (CFP) | 151, p. 3 |
| June 1968 | Requirement issued | 137, p. 52 |
| 8 August 1968 | RFP released for F-15 attack radar | |
| 9 August 1968 | Revised CFP and a Technical Development Plan (TDP) | 151, p. 3 |
| 27 August 1968 | AF awards initial development contracts for the F-15 engine to Pratt and Whitney and GE | |
| 16 September 1968 | DoD Development Concept Paper outlines guidelines for F-15 program | 151, p. 3 |
| 28 September 1968 | DCP appoved--AF authorized to proceed with contract definition | 151, p. 3 |
| 30 September 1968 | RFP released to eight manufacturers, four respond | 151, p. 3 |
| 24 October 1968 | F-X redesignated F-15A | |
| 19 November 1968 | F-15 contract proposal evaluation begins | |
| 31 December 1968 | AF announces award of definition contracts to North American, McDonnell Douglas and Fairchild | 151, p. 4 |
| 13 February 1969 | Pratt and Whitney and GE receive competitive contracts to furnish data on engine-airframe compatibility for the F-15 designs | |
| June 1969 | System contract definition reports and proposals for development received from three manufacturers | 151 |
| 23 December 1969 (FSD start) | McDonnell Douglas named winner | 17, p. 370 |
| 1 January 1970 | F-15 program enters full scale development | 151 |
| April 1971 | Critical design review | |
| 27 July 1972 | First F-15A flight | 9, p. 344; 27, p. 343; 135 |
| 1 March 1973(a) | Production go-ahead for 30 operational aircraft | 27, p. 343 |

F-15 MCDONNELL DOUGLAS EAGLE--continued

| Date | Event | Source |
| --- | --- | --- |
| 14 November 1974 | Squadron delivery (inventory) | 27; 13; 8, p. 30 |
| September 1975 | IOC | |
| July 1977 | 200th delivery | |

(a) 135 dates "production decision" as February 1973. 39, p. 19, confirms the number 30 as the initial order. 9, p. 344, claims an order for 20 planes was approved in the spring of 1973.

F-16 GENERAL DYNAMICS

| Date | Event | Source |
|---|---|---|
| 1965-1970 | Industry supported design studies | |
| June 1970 | President's Blue Ribbon Panel Report issued; recommended abandoning Total Package Procurement and more use of competitive prototyping | 136 |
| September 1971 | Lightweight Fighter Program announced | 170 |
| 6 January 1972(a) | RFP issued for Lightweight Fighter (LWF) | |
| 18 February 1972(b) | Five aircraft manufacturers enter design competition: General Dynamics, Northrop, Boeing, LTV Aerospace and Lockheed | 9, p. 347 |
| 1 April 1972(c) (Prototype start) | AF awards LWF prototype contracts to General Dynamics and Northrop | 136 |
| 13 December 1973 | First YF-16 prototype rolled out | 27 |
| 8 January 1974 | YF-16 arrives at Edwards AFB | 27 |
| 20 January 1974 | Unscheduled first flight--pilot takes off during taxi tests | 27; 9, p.347 |
| 2 February 1974 | Official first flight of General Dynamics YF-16 | 27 |
| Spring 1974 | Iran, Belgium, Netherlands, Denmark, Norway interested in lightweight fighter; in June, a consortium (without Iran) is formed to find a replacement for the F-104 | |
| 9 May 1974 | Second YF-16 prototype's first flight | 9 |
| 9 June 1974 | Northrop's YF-17 makes first flight | 136 |
| 11 July 1974 | Written U.S. commitment setting source selection by 1 January | 165 |
| 7 August 1974 | General Dynamics and Northrop awarded "transition" contracts of $4 million to help them prepare full-scale development proposals | |
| 7 September 1974 | USAF issues formal proposal instructions for full scale development of ACF | |
| November/December 1974 | Proposals received and evaluated | |
| 13 January 1975 (FSD start) DSARC II | General Dynamics YF-16 wins; full-scale development contracts awarded | 74, p. 75; 27; 9; 97; 37, p.118; 86 |
| 7 June 1975 | European Consortium chooses F-16 | 27; 165 |
| 27 February 1976 | Required operational capability (ROC) TAF 303-76 published | |
| 20 October 1976 | First of eight full-scale development F-16s rolled out | 136; 77, p.19 |
| 8 December 1976 | First flight full-scale development F-16A | 136 |
| 13 October 1977 | DepSecDef authorizes full production | 166, p. i |
| 7 August 1978 | First flight production aircraft | 111, p. 159 |

F-16 GENERAL DYNAMICS--continued

| Date | Event | Source |
|---|---|---|
| 17 August 1978 | First production F-16 accepted by AF | 111 |
| 6 January 1979 | First operational F-16 delivered to TAC | 37, p. 118 |
| January 1981 (estimated) | 200th delivery | |

(a) RFQ, January 1972; RFP submitted to USAF in February 1972--170.
(b) 27, p. 299, gives 28 February.
(c) 27 gives April 13 as contract award date. 132, p. 71 does not give an exact date but rather says, "Early in 1972, General Dynamics was awarded a $38 million contract to develop and produce two YF-16s and Northrop $39 million for two YF-17s."

# F-18 MCDONNELL DOUGLAS HORNET

- o Single-seat, carrier-based naval strike fighter
- o Designed to replace F-4 fighter and A-7 attack aircraft and to complement the F-14

| Date | Event | Source |
|---|---|---|
| 1971 | U.S. Navy becomes concerned at cost of F-14 | 8, p. 32 |
| April 1972 | Lightweight fighter prototype program (YF-16, YF-17) started | See F-16 |
| 1973 | U.S. Navy studies low-cost versions and compares them with navalized F-15 versions and improved F-4s | 8, p. 32 |
| April 1974 | DoD accepts proposal from the U.S. Navy to study a low-cost lightweight multi-mission fighter, VFAX | 27, p. 346 |
| June 1974 | USN approaches manufacturers to submit critiques and concepts; USN has responses from six manufacturers | 27; 86 |
| 9 June 1974 | First flight of YF-17 | 9, p. 350 |
| 28 August 1974 | Congress terminates VFAX concept; changed to NACF program--Navy issues operational requirement for a new multi-mission aircraft | 27; 70, p.25 |
| Fall 1974 | Navy is directed to limit its competition to YF-16 (General Dynamics) and YF-17 (Northrop) derivatives | 70 |
| 12 October 1974 | Requests for quotation sent out to industry | 149, p. 6 |
| October 1974 | Northrop teamed with McDonnell | 170 |
| December 1974 | McDonnell and LTV respond with preliminary technical proposals | 149, p. 6 |
| December-January 1975 | McDonnell and LTV furnish additional data | 149, p. 6 |
| 15-16 January 1975 | Navy Source Selection officials meet and advise LTV and McDonnell on the shortcomings of their proposals | 149, p. 6 |
| January-February-March 1975 | Contractors submit revised proposals | 149, p. 6 |
| 28 April 1975 | Source Selection Authority selects McDonnell Model 267 | 149, p. 6 |
| 2 May 1975 | Public announcement of selection; initial short-term contract of $4.4 million to McDonnell Douglas/Northrop and $2.2 to GE | 27, p. 346<br>86; 70 |
| 9 May 1975 | LTV files formal bid of protest with GAO | 149, p. 2 |
| 1 October 1974 | GAO and House of Representatives uphold procurement decision; reject LTV's protest | 94; 149, p. 3 |
| 21 November 1975 | Full-scale development contract to General Electric for F404-GE-400 engine | 70 |
| December 1975 | DSARC II | |
| 22 January 1976(a) (FSD start) | Full-scale development contract with McDonnell Douglas for 11 R&D aircraft | 70, p. 25 |

F-18 MCDONNELL DOUGLAS HORNET--continued

| Date | Event | Source |
|---|---|---|
| September 1978 | F-18 rolled out | 70 |
| 18 November 1978 | First flight | 71, p. 19; 93 |
| July 1979 | Five aircraft have been delivered to Patuxent Naval Air Test Center | 87, p. 45 |
| May 1980 (estimated) | First production delivery | 71, p. 19 |

(a) 27 gives 28 January as contract date. 149, p. 2 gives 26 January.

A-3D DOUGLAS SKYWARRIOR

o First swept-wing jet attack bomber produced for the Navy
o Capable of carrying heavy loads of all types of weapons

| Date | Event | Source |
|---|---|---|
| 1947 | Discussions between Navy and Douglas; Bureau of Aeronautics outlines requirements for a bomber to operate from a large carrier | 18, p. 186; 120 |
| 1949 | Douglas completes design | 19; 18 |
| 31 March 1949(a) (Prototype start) | Two prototypes (XA3D-1) ordered | 18, p. 186; 19 |
| 28 October 1952 | First prototype flight (J40 engine) | 79; 18; 23, p. 239; 120 5, p. 168 |
| ? | Production orders placed | 5, p. 168 |
| 16 September 1953 | Airplane re-equipped with Pratt and Whitney J57-P-6 engine--first flight of this production version | 23; 5; 18; 120 |
| January 1955 | First acceptance from production batch | |
| 31 March 1956(b) | Enters operational service | 18, p. 187; 148 |
| June 1960 | 200th delivery | |

(a) There is no record of a subsequent, separate decision to initiate full-scale development.
(b) April 1956 is given as the date the A3D-1 "begins to reach the Fleet" in 32, p. 18.

## A-4 MCDONNELL SKYHAWK

- Simple, lightweight design
- Named "Heinemann's Hotrod"
- Originally designated A4D-1

| Date | Event | Source |
|---|---|---|
| 1951 | U.S. Navy requirement for a low-cost attack aircraft | 118 |
| 21 June 1952 (FSD start) | Initial development contract given Douglas for prototypes and preproduction aircraft | 18, p. 305 |
| | Navy inspects mock-up and places orders | 19 |
| September 1952 | Prototype construction begins | 27, p. 352 |
| 22 June 1954 | First prototype flight, XA4D-1 | 19; 118; 27 |
| 14 August 1954 | First flight, A-4A preproduction aircraft with J65-W-2 engine | 18, p. 306; 19 |
| August 1955 | First delivery--production batch | |
| 26 March 1956 | First flight A4D-2 (A-4B) | 26, p. 402 |
| 26 October 1956(a) | Deliveries begin to Navy Attack Squadron VA-72--enters operational service | 18, p. 306; 118; 19; 135 |
| December 1957 | 200th delivery | |
| 1977 | Deliveries neared 3,000 | 8, p. 84 |

(a) 148 lists 27 September 1956 as "squadron delivery" date.

A-5 NORTH AMERICAN VIGILANTE

- o Attack bomber designed to carry nuclear or conventional weapons over a range of several hundred miles at high altitudes, with an over-target speed of Mach 2
- o A3J designation changed to A-5 in 1962

| Date | Event | Source |
|---|---|---|
| 1955 | Navy requirement for a high-performance attack aircraft with all-weather capability | 19; 18, p.352 |
| 29 June 1956(a) (FSD start) | Letter contract to North American | 19; 18 |
| 29 August 1956(b) | First development order | 29, p. 361 |
| | Two prototypes ordered | 18; 19 |
| 31 August 1958(c) | First prototype flight | |
| January 1959 | Large follow-on production contract awarded North American | 26; 29, P. 361 |
| February 1960 | First production acceptance | 18, p. 353; 19 |
| June 1961 | Enters squadron service; VAH-7 is first operational unit to receive A-5 (did not reach 200th delivery) | 29, p. 361; 18; 11 |

(a) 29, p. 361, says a "letter of intent" was issued in June 1956. Actual contract followed on 29 August.
(b) 26, p. 412, dates prototype contract as September 1956. This contract apparently included provision for full-scale engineering and an initial production commitment because production deliveries began 18 months after first "prototype" flight.
(c) Three sources agree on the date but differ on designation: 26--YA-5A; 19--YA3J-1; and 11--XA3J-1.

## A-6 GRUMMAN INTRUDER

- World's first fully all-weather/night attack aircraft capable of detecting and identifying tactical or strategic targets and delivering conventional or nuclear weapons on them under zero-visibility conditions

| Date | Event | Source |
|---|---|---|
| 1956 | Requirement for a low-level, long-range strike aircraft for U.S. Navy service | 18 |
| May 1957 | Competition announced; eight manufacturers begin study | 27, p. 305; 29, p. 361 |
| 31 December 1957(a) (FSD start) | Source selection--Grumman G-128 proposal chosen out of 11 submitted | 18; 27; 11 |
| 26 March 1959(b) | First contract: initial order for eight development aircraft | 148; 18; 26, p. 353; 29 |
| 19 April 1960 | First flight, development aircraft | 29, p. 361; 148; 26, p. 353 11; 135 |
| April 1962 | First acceptance from production batch | |
| Late 1962 | First 10 production aircraft are flying | 18 |
| 1 February 1963(c) | First squadron delivery | 18; 26; 11; 148 |
| February 1967 | 200th delivery | |
| 1975 | Final delivery | 8, p. 71 |

(a) This assumes that FSD started immediately after source selection although contract was not signed until 15 months later. This assumption allows 27 months to first flight.

(b) 26, p. 354, notes that the A-6A was developed under the first cost-plus incentive contract placed by the U.S. Navy. Further, 26 states that an additional contract followed in March 1960 and the two contracts together covered the development of eight aircraft. 29 confirms that first contract was for only four aircraft.

(c) 29, p. 361 says A-6 did not reach operational service until 1964.

A-7 VOUGHT CORSAIR II

- o Attack aircraft developed by the U.S. Navy for carrier operation and subsequently flown by both the U.S. Navy and Air Force
- o Adopted by the AF virtually off the shelf, a precedent set by the McDonnell F-4

| Date | Event | Source |
|---|---|---|
| 1960 | Bureau of Naval Weapons (BUWEPS) study group recommends development of a new Navy attack a/c to take advantage of new turbofan jet engine, TF-30 | 138, p. 7 |
| 1960-1962 | Discussions on visual attack light (VAL) a/c continue | 138, p. 7 |
| November 1962 | Chief of Naval Operations asks BUWEPS for its VAL recommendations | 138, p. 7 |
| December 1962 | Sea Based Air Strike Study Group formed | 138, p. 8 |
| Early 1963 | Group briefs a meeting of eight aircraft contractors on purpose of study--solicit help of entire industry | 138, p. 8 |
| April 1963 | Group continues to meet with contractors to study plan | 138, p. 9 |
| May 1963 | Navy Sea Based Strike Study recommends a follow-on visual attack carrier aircraft to replace the A-4 | 140 |
| 17 May 1963(a) | USN initiates design competition for a light attack aircraft to replace the Douglas A-4 Skyhawk, SOR W11-26 drafted by Navy | 18; 151 |
| 24 May 1963 | Synopsis of A-7 requirements transmitted to industry | 140 |
| 29 June 1963 | Formal Request for Quotation distributed to industry | 140 |
| 12 August 1963 | North American, Douglas, LTV submit proposals | 138 |
| 4 November 1963 | Navy evaluates proposals | 140 |
| 13 November 1963 | Secretary of the Navy approves LTV selection as prime contractor | 140 |
| 11 February 1964 | Ling-Temco-Vought named winner | 27; 18; 29, p. 362 |
| 19 March 1964 (FSD start) | Contract awarded LTV--seven A-7As for flight testing and first 35 production aircraft | 27; 18; 151; 138 |
| September 1965 | Second production contract for 140 additional F-7As | 18 |
| 27 September 1965(b) | First A-7A flies | 27; 18; 65 |
| March 1966 | First delivery from production batch | |
| 13-15 September 1966(c) | U.S. Naval Air Test Center receives first four aircraft | 27 |
| 14 October 1966 | Delivery to user squadrons begins | 27 |
| 1 February 1967 | VA-147 commissioned as the first A-7A tactical squadron | 18 |

A-7 VOUGHT CORSAIR II--continued

| Date | Event | Source |
|---|---|---|
| January 1968 | 200th delivery | |
| 26 September 1968 | First A-7D flies with Allison's TF 41-A-1 engine | |
| 11 December 1968 | First A-7D aircraft (#5) accepted by the AF at LTV facilities in Dallas | |

(a) 138 dates the Specific Operational Requirement W11-26 as 17 May and says the RFP was not distributed until the following month.
(b) 29, p. 362 dates first flight as 25 September 1965.
(c) 18, p. 293 states that September and October mark delivery dates to first two "training units."

## A-10 FAIRCHILD

| Date | Event | Source |
|---|---|---|
| 8 September 1966 | Gen. John J. McConnell, USAF Chief of Staff, initiates design of a specialized close-air-support aircraft; issues Chief of Staff Decision Letter | |
| December 1966 | SOR/RAD (AX Design for Advanced Attack Aircraft) | 170 |
| 6 March 1967 | RFPs issued to 21 companies for design studies of a new, low-cost attack aircraft, the A-X | |
| 2 May 1967 | Close Air Support (CAS) study contracts to General Dynamics/Convair, Grumman, McDonnell Douglas, and Northrop | |
| June 1968 | AF develops initial concept formulation package for the A-X | |
| December 1968 | Initial decision coordinating paper (DCP) is approved | |
| September 1969 | Supplemental CFP studies completed | |
| December 1969 | Milestone I DSARC Review | |
| April 1970 | DepSecDef approves the A-X for competitive prototype development | |
| 7 May 1970 | RFP issued to 12 airframe manufacturers | |
| 10 August 1970 | Six aircraft companies submit proposals | |
| 18 December 1970 (Prototype start) | Development contracts awarded to Northrop and Fairchild (competitive prototype development phase)--DSARC I | 157 |
| 1 March 1971 | AF designates A-X prototypes: Northrop, A-9; Fairchild, A-10 | |
| October 1971 | Engineering prototype designs complete | 157 |
| May 1972 | First prototype flights: A-9, May 30; A-10, May 10 | |
| 18 January 1973 (FSD start/DSARC II) | AF announces Fairchild's A-10 winner | 27, p. 293 |
| 28 February 1973 | AF awards contracts to Fairchild and General Electric | 157 |
| 31 July 1974 | DoD releases $39 million to proceed with initial production of 52 A-10s | |
| December 1974 | First flight DT&E | |
| February 1975 | First DT&E aircraft delivered; IOT&E using preproduction aircraft begins | |
| 15 February 1975 | First preproduction flight, DT&E at Edwards AFB | |
| October 1975 | First A-10 operational | 170 |
| 21 October 1975(a) | First production A-10 completes first flight | |

A-10 FAIRCHILD--continued

| Date | Event | Source |
|---|---|---|
| November 1975 | First production aircraft delivered | 135; 157 |
| 5 March 1976 | IOT&E testing ends | |
| 20 March 1976 | Turnover of the A-10 from the developing command, AFSC, to the using command, TAC--ceremony | |
| March 1977 | First combat-ready A-10 wing | |
| 1 July 1977(b) | First operational squadron of A-10s activated | 157 |
| October 1977 | First squadron achieves IOC | 37 |
| May 1979 | 200th delivery (estimated) | |

(a) 135 reports first production flight as April 1976.
(b) 37, p. 119, says June.

B-47 BOEING STRATOJET

o First jet bomber to serve in quantity with Strategic Air Command

| Date | Event | Source |
|---|---|---|
| Autumn 1943 | AF invites Boeing and several other manufacturers to study jet bomber designs; AF outlines its tentative requirements | 17, p. 114; 67 |
| March 1944 | Boeing submits design for Model 424: straight-wing fuselage and tail unit like B-29 | 17, p. 114; 67 |
| April 1944 | AF preliminary characteristics for medium bomber | 67 |
| August 1944 | ADO issued | |
| November 1944 | GOR/SOR issued | |
| December 1944 | Boeing Model 432 Phase I contract awarded | 29, p. 147; 17, p. 114 |
| June 1945 | Construction of mock-up authorized | 17 |
| September 1945 | Model 448 with swept-back wing proposed | 29, p. 147; 17, p. 114 |
| October 1945 (Prototype start) | Model 450 with external jet nacelles at various locations proposed--go-ahead from AF | 17, p. 114; 29, p. 147; 67 |
| April 1946 | Mock-up approved; Boeing receives L/C for Model 450; construction of two airplanes, spare parts, and tools authorized for Phase II | 29, p. 147; 17, p. 115 |
| June 1946 | Prototype construction begins | 17, p. 115; 29, p. 147 |
| 12 September 1947 | First XB-47 rolls out 17 months after AF approval | 67; 2 |
| 17 December 1947 | First flight of XB-47 prototype | 21, p. 204; 17, p. 147; 19; 67; 5, p. 148 |
| 21 July 1948 | Second prototype flies with more powerful J47 | 21; 17, p. 115 |
| 3 September 1948 (FSD start) | Letter of intent to Boeing for $30 million to build the A model | 67 |
| November 1948(a) | L/C awarded for 10 planes | 67 |
| November 1948 | First prototype accepted by AF | 17, p. 115; 67 |
| December 1948 | Second prototype accepted; flight testing begins | 17; 67 |
| 7 October 1949 | First XB-47, re-equipped with J47 engine, makes first flight | 17 |
| 1 March 1950(b) | First B-47A completed | 67 |
| 25 June 1950 | First production B-47A flies | 19; 17, p.116 |
| December 1950 | Delivery of A models begins | 17; 67 |
| March 1951 | First B-47B completed | 67 |

B-47 BOEING STRATOJET--continued

| Date | Event | Source |
|---|---|---|
| 26 April 1951 | First B-47B flies | 17, p. 116 |
| Mid-1951 | Deliveries of the B-47B begin | 17, p. 116 |
| August 1951 | First B-47 assigned to SAC | 75, p. 25 |
| June 1952 | 200th delivery | |

(a) 17 states that September is the contract date. 29, p. 148 gives October 28 as the date on which 10 B-47As were ordered at a cost of $37 million. 5, p. 148 confirms the number 10.

(b) 29, p. 148, gives 1 March as the date of first flight of the B-47A with the J47-GE-11 engine.

# B-52 BOEING STRATOFORTRESS

- o Still constitutes the major piloted element of SAC
- o Capable of delivering a wide range of weapons, including conventional and nuclear bombs
- o In third decade of service with USAF

| Date | Event | Source |
|---|---|---|
| April 1945 | Design study begins; AF indicates interest to Boeing for turbine-powered long-range bomber | 17, p. 120 |
| November 1945 | GOR/SOR issued | |
| January 1946 | AF releases a new set of requirements for a heavy bomber; invites industry to submit | 29, p. 152; 99; 91 |
| June 1946 | Source Selection; Boeing wins contract for further development | 17, p. 120; 91 |
| Late 1947 | Contract for new full-scale mock-up | 91 |
| July 1948 (Prototype start) | Boeing receives contract for two prototypes | 17, p. 120; 29, p. 152 |
| 27 October 1948 | Design accepted | 29, p. 152 |
| April 1949 | Mock-up approved | 29, p. 152 |
| February 1951 (FSD start) | Production order for 13 B-52s | 17, p. 121 |
| 29 November 1951 | XB-52 moved out of factory for ground test | 17, p. 120; 91 |
| 15 March 1952 | YB-52 rolled out | 17, p. 121; 91 |
| 15 April 1952 | First flight YB-52 | 22, p. 205; 29, p. 152; 91; 135; 17, p. 121 |
| 2 October 1952 | XB-52 makes first flight | 29, p. 152; 23, p. 215; 17, p. 120 |
| 18 March 1954 | First production B-52 rolled out | 53, p. 278 |
| 5 August 1954 | First production B-52A flight | 29, p. 152; 23, p. 215; 17, p. 121 |
| 1955 | B-52 enters service | 17, p. 120; 37, p. 116 |
| 29 June 1955 | First deliveries of RB-52B to SAC | 17 |
| January 1956 | $248 million contract to Boeing | 125 |
| August 1957 | 200th delivery | |

## B-58 CONVAIR HUSTLER

- First supersonic strategic bomber put into production for the USAF
- Three seater, no internal weapons bay
- Ordered as one of the first systems under the "weapon system concept"

| Date | Event | Source |
|---|---|---|
| October 1946 | ADO issued | |
| March 1949 | GEBO II generalized bomber studies indicate B-58 feasible | 92, p. 52 |
| 1949-1950 | Convair conducted an exhaustive study for USAF to determine technical feasibility and general configuration of a supersonic bomber | 69, p. 112 |
| 1949 | Convair designs win AF competition | 17, p. 174; 25, p. 288 |
| 17 February 1951 | Letter contract for partial Phase I development awarded to Convair | 156 |
| 26 February 1951 | Letter contract for partial Phase I development awarded to Boeing | 156 |
| October 1951 | Definitive contract negotiated with Convair for Phase I: wind tunnel tests and design studies, prior to construction of a mock-up | 156 |
| 8 December 1951 | GOR published | 92; 156 |
| 28 February 1952 | Plans made to terminate Project MX-1626 (Convair) because of lack of funds, but $100,000 increment granted to extend program through March 1952 | 156 |
| 10 March 1952 | Major realignment of MX-1626 | 156 |
| 12 March 1952 | General Phase I program initiated with Boeing and Convair: work limited to generalized design studies to narrow the range of alternatives | 156 |
| 15 May 1952 | Definitive contract supersedes letter contract to cover general Phase I development | 156 |
| 9 October 1952 | WADC recommends to HQ ARDC that MX-1964 be selected | 156 |
| 18 November 1952(a) | Convair MX-1964 selected over Boeing | 156 |
| 12 February 1953 (FSD start) | Convair given complete go-ahead for detailed Phase I development program | 156 |
| 17 February 1953 | Letter contract authorizing preproduction planning to permit procurement of 18 weapon systems; detailed engineering; manufacturing of tools and fabrication of parts | |
| August 1953 | Mock-up inspected | 29, p. 154 |
| 13 October 1954(b) | Contract for 13 aircraft | 19; 29, p. 154 |
| 11 November 1956 | First flight of experimental airplane (J79-GE-1 turbojet engine) | 17, p. 174; 19; 29, p. 154; 5, p. 156; 25, p. 288 |

B-58 CONVAIR HUSTLER--continued

| Date | Event | Source |
|---|---|---|
| 4 December 1956 | First supersonic flight of B-58 | 156 |
| February 1957 | Second prototype's first flight | 25; 17, p. 14 |
| Spring 1957(c) | Additional order of 17 aircraft added to original 13 | 25 |
| September 1959(d) | First production B-58A flies | 17, p. 174; 15, p. 42 |
| November 1959(e) | First production acceptance (aircraft #31) | |
| 15 March 1960(f) | SAC receives first B-58A with J79-GE-5A engine | 17, p. 175; 29 |
| | Did not reach 200th delivery | |

(a) 17 and 12 give August 1952 as Convair MX-1964 selection and contract date. 25 agrees on August.
(b) 29, p. 154, gives this date as the ordering of first 13 aircraft. 19 and 25 agree first order is for 13 but do not give date.
(c) In 19 and 40, October is noted for the ordering of 17 planes.
(d) This was the 31st airplane produced.
(e) 29, p. 155 gives September 1959 as date of delivery. Two other sources (25 and 54) give December 1959 as first production delivery, and 15 specifically gives 1 December 1959.
(f) 25 states that in 1960 the B-58 reached operational status. 69 agrees.

B-70 NORTH AMERICAN VALKYRIE

| Date | Event | Source |
|---|---|---|
| 14 October 1954 | Original USAF requirement issued, GOR 38, for an Intercontinental Bombardment | 25 |
| 1955 | Designated Weapon System 110A | 25 |
| 18 February 1955 | System Requirement 22 issued | 147 |
| 22 March 1955 | GOR 38 superseded by GOR 82 | |
| 13 July 1955 | Joint ARDC-AMC Source Selection Board proposed a list of six contractors | |
| 8 November 1955 | Boeing and North American (the only contractors to submit proposals) were given Phase I development contracts | |
| 23 December 1957 | North American was selected as prime contractor for Phase I | 25 |
| 24 January 1958 | Letter contracts signed with North American and GE | 147 |
| 7 March 1958 | Revised GOR 82 published; greater emphasis placed on speed | 147 |
| 19 March 1958 | Acceleration of program announced | 147 |
| 7 October 1958 | B-70 program set back to slower pace | 147 |
| 11 August 1959 | Decision to use high energy fuel abandoned; J-93-GE-5 engine canceled and J-93-GE-3 turbojets substituted | 147 |
| December 1959 | Program cut back to one prototype | 25; 147 |
| Mid-1960 | Partial restoration of budget cut | 25 |
| 31 October 1960 | Announcement that $265 million would be available for the B-70 program | 25 |
| March 1961 | President Kennedy stated that B-70 development as a full weapon system is unnecessary; suggests program be continued to explore flying at Mach 3; wanted only a few experimental prototypes | 25a |
| March 1963 | Decision to build only two XB-70A for aerodynamic research | 25a |
| 11 May 1964 | First public showing | 25a |
| 21 September 1964 | First flight, first prototype | 25a |
| 12 October 1964 | Mach 1 exceeded (3rd flight) | 25a |
| 17 July 1965 | First flight, second XB-70A | 25a |
| 14 October 1965 | Mach 3 first attained (17th flight) | 25a |
| 8 June 1966 | Second XB-70A lost when it collided with F-104 | 25a |
| 25 March 1967 | NASA takes over program management | 25a |

B-1 NORTH AMERICAN ROCKWELL

| Date | Event | Source |
|---|---|---|
| 1962 | Informal design studies began | 27, p. 388 |
| September 1963 | DepSecDef approved $15 million in FY 1965 funds to initiate development of a penetrating strategic aircraft | 151 |
| October 1963 | Approval changes; funds reduced to $5 million to provide for aircraft studies only | 151 |
| April 1964 | Advanced Manned Strategic Aircraft SPO established | |
| July 1964 | Funded studies started | |
| April 1965 | Requirement issued for an Advanced Manned Strategic system | 27 |
| 20 November 1968 | B-1 Development Concept Paper approved by the DepSecDef. This DCP approved a competitive design approach aimed at reducing the lead time from development to operational use without a commitment to FSD | 151 |
| Early 1969 | The SecDef changed the procurement plan from a competitive design approach to a full-scale engineering development program to be initiated in FY 1970 | 151 |
| 3 November 1969 | DoD issued RFP to industry (three air-frame and two engine finalists) | 27 |
| 14 January 1970 | Airframe proposal due-date | 47a |
| 10 February 1970 | Economic proposals due | 47a |
| 4 June 1970 | DSARC authorization to proceed into full-scale developmment | |
| 5 June 1970 (FSD start) | Research, development, test, and evaluation contracts awarded to Rockwell and GE (original cost-plus-incentive contract for five flying prototypes, two structural test airframes and 40 engines) | 27 |
| January 1971 | Design of the B-1 frozen. Contract quantities reduced to three flight test aircraft, one ground test aircraft, and 27 engines | 27 |
| 26 October 1974 | First B-1 bomber prototype | 49 |
| 23 December 1974 | First flight successfully completed | 50, p. 12 |
| 10 April 1975 | First supersonic flight | 51, p. 17 |
| FY1976 Budget | Procurement of a fourth test aircraft as a preproduction prototype approved | 27 |
| 1 April 1976 | No. 2 prototype flies | 52 |
| 14 June 1976 | Third prototype flies | 52, p. 32 |
| October 1976 | Production decision scheduled | 50, p. 12 |
| December 1976 | DSARC III (production go-ahead) | |
| 30 June 1977 | President Carter announced that production of the B-1 would be canceled | 27a |

## C-5A LOCKHEED GALAXY

- o Large, long-range, heavy logistic aircraft
- o Developed under Total Package Procurement Concept (TPPC)
- o Able to operate from short landing fields and unpaved runways
- o Cargo volume is four times greater than C-141

| Date | Event | Source |
|---|---|---|
| 1963 | CX-4 requirement issued by the USAF's Military Air Transport Service for a large logistics transport aircraft | 17, p. 356 |
| 1964 | C-5A studies confirmed that concept of heavy logistics transport is feasible | 141 |
| 25 March 1964 | AF released SOR 214 for a heavy logistics aircraft system | |
| May 1964 | Initial design competition. Boeing, Douglas, and Lockheed invited to develop their initial designs further. Pratt and Whitney and General Electric invited to develop accompanying powerplant | 27, p. 338 |
| 11 December 1964 | RFP released to contractors | 151 |
| 31 December 1964 | AF awarded program definition contracts | |
| April 1965 | Proposals received--AF Source Selection Board begins evaluation | 151 |
| August 1965 | Source Selection Board recommends Boeing | 151 |
| 1 October 1965(a) (FSD start) | General Electric and Lockheed proposals selected. Contract for five RDT&E aircraft plus an initial run of 53 aircraft | 141; 27, p. 338; 158; 151 |
| December 1965 | $1,400 million to cover development and production of first 58 C-5As | 100 |
| August 1966 | Initial construction begins | 27 |
| 2 November 1967 | GAO begins investigation of C-5A program | 153 |
| February 1968 | Roll-out of first aircraft | 158 |
| 30 June 1968 | First of five development aircraft flies | 27; 158; 17; 98 |
| 30 June 1969 | C-5A Category II testing began | |
| October 1969 | Delivery of first operational aircraft | 158 |
| 17 December 1969 | First delivery to MAC | 17, p. 356; 37, p. 122; 8, p. 173 |
| June 1970 | Enters operational service | 48, p. 40 |
| September 1970 | IOC | 158 |
| May 1973 | Final delivery. Deliveries do not reach 200 | 8, p. 173 |

(a) Source selection date: 30 September 1965--167.

C-130 LOCKHEED HERCULES

o First transport produced under weapon system concept
o Has been in service 25 years

| Date | Event | Source |
|---|---|---|
| 1951 | Development starts after USAF decision to equip with turboprop transports | 17, p. 350 |
| 18 January 1951 | ADO issued | |
| January 1951 | USAF issues requirement for medium transport and work begins | 24, p. 316; 89, p. 93 |
| 12 March 1951 | GOR/SOR issued | |
| 2 July 1951 (Prototype start) | Source Selection: Lockheed | 89 |
| 11 July 1951 | Contract for two prototype YC-130s | 17, p. 350 |
| August 1951 | Work begins at Lockheed-Burbank on two prototypes | 89, p. 93 |
| September 1952(a) (FSD start) | Production contract | 17, p. 350; 146 |
| 23 August 1954 | First prototype YC-130 flight | 89; 5, p.181; 17, p. 350; 135; 81, p. 15 |
| March 1955 | First production model rolled out | 81 |
| 7 April 1955 | First production C-130A flies | 5, p. 181; 89 |
| December 1955(b) | First acceptance from production lot | |
| 9 December 1956 | Deliveries begin to Troop | 17, p. 350; 24 89; 146; 37, p. 122 |
| 1 June 1957 | First wing combat ready | 90, p. 32 |
| February 1959 | 200th delivery | |

(a) 24 gives 19 September 1952 as date of "prototype contract."
(b) 146 gives September 1955 as date of a conditional acceptance.

C-133 DOUGLAS CARGOMASTER

| Date | Event | Source |
|---|---|---|
| 1952 | Operational requirement for a heavy strategic freighter | 17, p. 272 |
| February 1953 (FSD start) | Douglas design accepted. Detail design work begins | 17, p. 272; 24, p. 282 |
| 1954 | Production contract for 35 aircraft. No prototypes built (six preproduction aircraft, however) | 11; 17, p.272; 5, p. 161; 8 |
| 31 January 1956 | C-133 rolled out from Douglas, Long Beach | 68, p. 186 |
| February 1956 | First C-133A completed | 24, p. 161 |
| 23 April 1956 | First flight C-133A | 5, p. 161; 24; 17, p. 272; 8, p. 177 |
| End of January 1957 | Four planes had been delivered to AF for testing | 24 |
| 29 August 1957(a) | First operational C-133 delivered | 24; 17, p. 272; 5, p. 161 |
| 31 October 1959 | First flight C-133B | 8, p. 177 |
| 1961 | Delivery completed (did not reach 200th delivery) | 8, p. 177 |

(a) Fuselage shape changed after first seven aircraft.

## C-141 LOCKHEED STARLIFTER

- First jet aircraft designed from the outset as a military cargo airplane
- Its purpose was to provide fast transportation over global ranges for the USAF Military Airlift Command and on strategic routes for Strike Command
- Equipped with all-weather landing system

| Date | Event | Source |
|---|---|---|
| 4 May 1960 | SOR 182 issued for a large capacity intercontinental cargo jet | 17 |
| 13 March 1961 | Design competition. Lockheed named winner over Boeing | 17; 59, p. 762 |
| April 1961 | Letter contract | 146, p. 3-1 |
| May 1962(a) | Definitive contract for five aircraft | 146, p. 3-2 |
| August 1963 | Roll-out, Lockheed-Marietta | 41 |
| August 1963 | First AF acceptance | 146, p. 3-2 |
| 17 December 1963 | First development C-141A flies from Dobbins AFB, GA | 17, p. 354; 103, p. 8 |
| May 1964 | Definitive contract for 127 aircraft | 146, p. 3-2 |
| 19 October 1964(b) | First production delivery | 17, p. 354; 135; 146. p. 3-1 |
| 23 April 1965 | Begins squadron operations with MAC | 17, p. 354; 37, p. 124 |
| April 1967 | 200th delivery | |
| July 1968 | Final delivery | 8, p. 174 |

(a) 17 gives 16 August 1961, as the date of the contract for five development C-141As.

(b) This assumes that the first three aircraft of the production lot were used for development testing.

KC-135 BOEING STRATOTANKER

- High speed, high altitude capability
- Standard USAF tanker in the 1960s
- Used as a tanker, cargo or personnel transport

| Date | Event | Source |
|---|---|---|
| 20 May 1952 (Prototype start) | Development of a Boeing jet transport prototype begins--"DASH 80" | 17, p. 126; 85; 142 |
| August 1952 | Boeing announces it is developing prototype (investing $15 million of its own funds) | 142 |
| May 1953 | Prototype mock-up | |
| November 1953 | Gen. Curtis LeMay issues a requirement for 200 jet tankers to support future B-52 and B-58 fleet | 142 |
| March 1954 | Design initiated | |
| May 1954 | DASH 80 rolled out | 142 |
| | Hq ARDC invites Lockheed, Convair, Douglas, Boeing, Fairchild, and Martin to submit proposals for an advanced jet tanker | 142 |
| 15 July 1954 | First DASH 80 prototype flight | 17, p. 126 |
| 5 August 1954(a) (FSD start) | AF announces purchase of a limited number of the Model 707 jet transports--cost: $240 million | 25, p. 270; 128 |
| 2 March 1955 | AF decides to order substantially more aircraft--brings total order to $700 million | 128 |
| 18 July 1956 | KC-135A rolls out | 25; 82, p. 11 |
| 31 August 1956 | First flight KC-135A | 25; 17, p. 126 37, p. 123 |
| 31 January 1957 | First KC-135A accepted by AF | 17, p. 126; |
| 18 June 1957 | Becomes operational. Initial delivery to Castle AFB | 25; 17 |
| January 1959 | 200th delivery | |
| Mid-1966 | Final delivery | 8, p. 156 |

(a) 17 gives 5 October as the Air Force announcement date of the initial purchase of 29 KC-135s. 8 also chooses October as the order date for 29 aircraft. 142 adds, "Because of SAC's urgent tanker requirements and logistics constraints, the competition idea was dropped and Boeing was chosen sole source contractor."

# P-3 LOCKHEED ORION

- o Four-engine, turboprop, land-based ASW patrol plane
- o Based on the commercial turboprop, Electra
- o Replaced the P2V/P-2 Neptune and P5M/P-5 Marlin as the U.S. Navy's standard patrol aircraft

| Date | Event | Source |
|---|---|---|
| 1954 | Design of the Electra began to meet requirements set by American Airlines for a short-medium range transport | 4 |
| June 1955 | American and Eastern Airlines buy Lockheed's model L-188. Combined order: 75 a/c | 4 |
| Mid-1956 | Navy considers alternative to P-2. Works with Lockheed on Model CL-353. Electra goes into serial production about this time | |
| August 1957 | USN calls for design proposals to provide a replacement for the P-2 Neptune. Manufacturers to modify aircraft already in production | 18, p. 278 |
| December 1957 | Lockheed submits Electra proposal to Navy | |
| 6 December 1957 | First commercial Electra flies | 4 |
| 24 April 1958 (FSD start) | Lockheed wins Navy competition with adaptation of commercial Electra turboprop. R&D contract issued for P-3 system | 18; 29, p. 318; 26 |
| 19 May 1958 | Fifth Electra flies (this is first aircraft delivered to the airlines) | 4 |
| 19 August 1958 | First P-3 prototype flight (modified Electra) | 26; 18; 14 |
| September 1958 | Mock-up review | |
| 12 January 1959 | Electra enters commercial service with Eastern | 4 |
| 25 November 1959 | First flight of second prototype, YP3V-1, with full electronics | 29, p. 318; 26; 11; 18 |
| October 1960 | Seven production planes ordered | 29, p. 318 |
| Late 1960 | Name "Orion" adopted | 18 |
| 15 April 1961(a) | First flight production P-3A | 11; 26 |
| March 1962(b) | First acceptance of operational configuration | |
| December 1966 | 200th delivery | |

(a) There is much confusion on the flight date of the first production P-3A. 150 claims March is the correct date. 18 and 29 confirm 15 April but call it first flight of the preproduction P-3A.

(b) Assumes first lot of seven aircraft were for test (supported by 18, who say six aircraft were used for flight test and evaluation). Actual squadron delivery was not until mid-1962. Delay of squadron service was presumably due to avionics system. (18 and 26 give 13 August 1962 as squadron delivery date; 11 confirms August while 29 and 14 agree on July.)

## S-3 LOCKHEED VIKING

- Carrier-based anti-submarine search and strike aircraft (VSX)
- Compact, high-wing monoplane powered by two GE TF34 turbofan engines in underwing pods

| Date | Event | Source |
|---|---|---|
| February 1965 | Tentative requirement by Chief of Naval Operations as follow-on to Grumman S-2E | |
| November 1965 | Navy requested an expression of interest by aircraft manufacturers to perform concept formulation studies | |
| December 1965 | SOR issued. Ten companies respond | 163 |
| | Study contracts awarded to Lockheed-California and McDonnell Douglas | |
| December 1967 | Release of RFP to five manufacturers: General Dynamics/Convair, Grumman, McDonnell Douglas, North American Rockwell, and Lockheed-California | 163; 17 |
| April 1968 | Five manufacturers submit proposals | 11 |
| August 1968 | Award of contract definition contracts | 163 |
| | Lockheed and General Dynamics asked to refine their proposals | 11 |
| 23 December 1968 | Lockheed and General Dynamics submit new proposals | |
| 1 August 1969 (FSD start) | USN issues Engineering Development contract to Lockheed for six prototypes | 163 |
| 4 August 1969 | Lockheed announces receipt of $461 million contract | 27, p. 328 |
| March 1970 | Full-size mock-up completed | 163; 11 |
| 8 November 1971(a) | First development aircraft rolls out | 11; 27; 115, p. 38; 101, p. 18 |
| 21 January 1972(b) | First flight development aircraft | 11; 27; 8, p. 146 |
| 4 May 1972 | USN announces order for 13 S-3As, first production lot | 27, p. 329 |
| November 1973 | First S-3A carrier landing (USS Forrestal) | 17, p. 282 |
| Late 1973(c) | Deliveries begin to U.S. Navy | 11 |
| 20 February 1974(d) | Officially introduced to fleet | 27, p. 329; 8 |
| July 1975 | First operational deployment | 27 |

(a) 27 claims 8 November is the date of the first R&D flight.
(b) 48a states first flight is scheduled for early January (1972).
(c) 17, p. 282 says that "deliveries to the Air Anti-Submarine (Training) Squadron 41 (VS-41) begin in February 1974 for crew training."
(d) Service delivery occurs October 1973--8, p. 146. This assumes that the first four development aircraft were used for testing.

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# Appendix B

# A COMPENDIUM OF HELICOPTER PROGRAM MILESTONES

CONTENTS

AH-1 HUEYCOBRA (Bell Model 209)

| Date | Event | Source |
|---|---|---|
| March 1965 | Design work begins | 6, p. 269 |
| | The original prototype was developed solely on the initiative of the Bell Helicopter Company through its Independent Research and Development Program | 36, p. 21 |
| 7 September 1965 | First prototype flight | 6, p. 269; 11, p. 210; 35, p. 188 |
| October 1965 | Department of the Army authorizes the Army Materiel Command to conduct "comparative" test of the Piasecki 16H, the Boeing-Vertol CH-47A (modified) and the Bell Model 209 at Edwards AFB | 37, p. 35 |
| December 1965 | Prototype delivered to U.S Army for testing and evaluation | 6, p. 269; 11, p. 210 |
| 11 March 1966 | U.S. Army announces HueyCobra will be produced | 6, p. 269; 11, p. 210; 35, p. 188 |
| 4 April 1966 | Bell announces receipt of development contract for two "preproduction" helicopters, designated AH-1G | 6, p. 269; 11, p. 210; 37, p. 35 |
| 13 April 1966 | U.S. Army issues initial production contract for about 100 AH-1G helicopters | 6, p. 269; 11, p. 210; 37, p. 35 |
| June 1967 | First delivery of AH-1G | 6, p. 269; 12; 36, p. 21 |
| 8 October 1967 | Initial deployment of AH-1G in Vietnam | 6, p. 269; 12; 13, p. 30 |
| March 1968 | USMC requests funds for AH-1J (twin-turbine version, designated "SeaCobra") | 14, p. 18 |
| May 1968 | Initial production order for 49 AH-1J SeaCobras | 6, p. 270; 12 |
| 1969 | USMC acquires 38 AH-1G's for training and transitional deployment pending delivery of the AH-1J | 6, p. 269 |
| 14 October 1969 | Preproduction AH-1J displayed | 7, p. 240 |
| Mid-1970 | First production AH-1J delivered | 6, p. 270 |
| March 1973 | First delivery of preproduction AH-1Q to U.S. Army for firing tests. (The AH-1Q is an anti-armor version of the AH-1G that fires TOW missiles and has helmet site subsystem) | 15, p. 9 |
| January 1974 | U.S. Army awards contract to Bell to convert 101 AH-1Gs to the AH-1Q configuration | 6, p. 270 |
| | A total of 290 AH-1Q conversions was ordered, but after 92 had been completed, the AH-1Q program was terminated in favor of two improved models, the AH-1R (without TOW) and the AH-1S (with TOW) | 36, p. 21 |

AH-1 HUEYCOBRA (Bell Model 209)--continued

| Date | Event | Source |
|---|---|---|
| 10 June 1975 | First delivery of production AH-1Q to U.S. Army | 6, p. 270 |
| 1975-1976 | U.S. Army awards contract for new production of advanced version of AH-1Q, designated AH-1S | 7, p. 240 |
| 16 March 1977 | First delivery of new production AH-1S | 7, p. 240 |

AH-64 (AAH) BLACK HAWK (Hughes Model 77)

| Date | Event | Source |
|---|---|---|
| 7 August 1972 | U.S. Army Systems Acquisition Review Council recommends ending Boeing-Vertol Cheyenne program | 4, p. 7 |
| 10 November 1972 | RFP for advanced attack helicopter released | 4, p. 8; 12 |
| 22 June 1973 | U.S. Army awards Phase I development contracts to Bell and Hughes for airframe and full system | 16, p. 11; 4, p. 12; 7, p. 320 |
| 19 April 1975 | Bell begins airframe ground tests | 17, p. 35; 4, p. 21 |
| June 1975 | Hughes begins airframe ground tests | 4, p. 21; 7, p. 320 |
| 30 September 1975 | First prototype flight of Hughes YAH-64 | 18, p. 23; 4, p. 21; 36, p. 44 |
| 1 October 1975 | First prototype flight of Bell YAH-63 | 18, p. 23; 4, p. 21 |
| February 1976 | U.S. Army changes armament and targeting requirements | 4, p. 30 |
| May 1976 | Hughes delivers first prototype to U.S. Army for flight tests | 36, p. 44; 7, p. 32 |
| June 1976 | Bell delivers first prototype to U.S. Army for flight tests | 4, p. 23 |
| September 1976 | U.S. Army changes machine gun ammunition requirements | 4, p. 30 |
| 30 September 1976 | Government Competitive Testing ends | 4, p. 23 |
| 27 November 1976 | TADS/PNVS proposals submitted | 12 |
| 10 December 1976 | U.S. Army awards Phase II development contract to Hughes | 4, p. 24; 42, p. 728 |
| 10 March 1977 | TADS/PNVS development contracts awarded | 12 |
| June 1979 | First prototype flights with TADS/PNVS systems | 41, p. 43 |
| January 1980 | Competitive flyoff between Northrop and Martin Marietta TADS/PNVS systems begin | 41, p. 43 |

CH-3, HH-3 JOLLY GREEN GIANT (Sikorsky S-61R)

| Date | Event | Source |
|---|---|---|
| November 1962 | USAF selects S-61R for transporting troops, cargo, personnel, or casualties | 2, p. 93 |
| 8 February 1963 | USAF orders 22 CH-3Cs | 10, p. 295; 36, p. 68 |
| 17 June 1963 | First prototype flight of CH-3C | 10, p. 295 |
| July 1963 | USAF announces CH-3C selected for long-range support system | 2, p. 93; 10, p. 295 |
| July 1963 | First flight of production CH-3C | 10, p. 295; 34, p. 258; 36, p. 68 |
| 30 December 1963 | First operational delivery of CH-3C for drone recovery duties at Tyndall AFB, Florida | 6, p. 454; 10, p. 295; 36, p. 68 |
| 30 December 1963 | S-61R receives FAA Type Approval | 10, p. 295 |
| February 1966 | USAF orders all CH-3Cs converted to uprated configuration, designated CH-3E | 6, p. 454; 11, p. 348; 24, p. 122 |
| | (Forty-two new CH-3Es were built in addition to the CH-3C conversions) | 36, p. 38 |
| | USAF Aerospace Rescue and Recovery Service used a version of the CH-3E designated HH-3E. It differed from the CH-3E in having armor, self-sealing fuel tanks, retractable flight refueling probe, defensive armament, and a rescue hoist | 11, p. 348 |
| | (Fifty CH-3Es were converted to the HH-3E standard) | 36, p. 68 |
| 1968 | First delivery of the HH-3F Pelican. The USCG used the HH-3F for extended search and rescue missions. While similar to the HH-3E, it is unarmed and has no armament but is fitted with advanced electronic search equipment | 36, p. 68 |

# CH-46, UH-46 SEA KNIGHT (Boeing-Vertol Model 107)

In 1956, Vertol began preliminary design and engineering of a twin-turbine transport for commercial and military markets. Vertol wanted to take advantage of the high power, small size and light weight of the shaft turbine engines that were then becoming available. The prototype work was performed entirely under company funding.

| Date | Event | Source |
|---|---|---|
| May 1957 | Construction of prototype begins | 8, p. 294; 10, p. 193 |
| 22 April 1958 | First prototype flight | 8, p. 294; 12; 11, p. 222 |
| July 1958 | U.S. Army orders ten Model 107s for evaluation | 3, p. 174 |
| 27 August 1959 | First flight of U.S. Army evaluation aircraft | 3, p. 174; 34, p. 246; 36, p. 32 |
| 25 October 1960 | U.S. Army tests begin | 8, p. 294; 10, p. 193 |
| February 1961 | USMC announces Model 107 as the winner of a design competition for a medium assault helicopter, designated CH-46A. Boeing-Vertol receives initial order for 14 aircraft | 3, p. 175; 12; 11, p.223; 36, p. 32 |
| 19 May 1961 | First flight of production CH-46 | 10, p. 193 |
| 26 January 1962 | Model 107 receives FAA Type Approval | 10, p. 193 |
| 16 October 1962 | First flight of production CH-46A | 8, p. 295; 11, p. 223; 34, p. 246; 12 |
| July 1964 | First operational delivery of the UH-46A to Utility Helicopter Squadron One, Ream Field, California. (The UH-46A is the USN version of the CH-46A) | 8, p. 294; 12 |
| 1 November 1964 | CH-46A officially accepted by USMC | 19 |
| November 1964 | USN Board of Inspection and Survey test completed (required for fleet release) | 8, p. 295; 11, p. 223 |
| December 1964 | First operational deployment | 12 |
| March 1966 | First deployment in Vietnam | 12; 11, p. 223 |
| September 1966 | First production CH-46D delivered from converted CH-46A production line. (The CH-46D is an uprated version of the CH-46A and all aircraft produced after September 1966 were of the 46D configuration) | 12 |
| September 1966 | First UH-46D delivered from converted 46A production line | 12 |

CH-47 CHINOOK (Boeing-Vertol Models 114/234)

| Date | Event | Source |
|---|---|---|
| 1956 | U.S. Army announces intention of replacing piston-engined transport helicopters with turbine-powered versions | 6, p. 290 |
| March 1959 | Boeing-Vertol Model 114 wins design competition | 6, p. 290; 3, p. 173 |
| June 1959 | U.S. Army/USAF Selection Board awards initial contract for five prototypes | 6, p. 290; 11, p. 224; 36, p. 34 |
| 1960 | First production contract for CH-47A | 11, p. 224 |
| 28 April 1961 | First prototype delivered for ground tests | 2, p. 23; 10, p. 195; 11, p. 224 |
| 21 September 1961 | First prototype flight | 2, p. 23; 10, p. 195; 11, p. 224; 34, p. 245 |
| 16 August 1962 | First production delivery of CH-47A | 2, p. 23 |
| December 1962 | First operational delivery of CH-47A to U.S. Army | 36, p. 34 |
| October 1966 | First flight of CH-47B. The CH-47B was developed from the CH-47A with larger engines, redesigned rotor blades, and other minor changes. | 3, p. 174; 11, p. 224; 34, p. 245; 36, p. 34 |
| 10 May 1967 | First delivery of CH-47B | 3, p. 174; 11, p. 224; 36, p. 34 |
| 14 October 1967 | First preproduction delivery of the CH-47C for testing. The CH-47C was a further development in the Chinook series with larger engines, strengthened transmission, and increased fuel capacity | 3, p. 174 |
| 14 October 1967 | First flight of CH-47C | 36, p. 34 |
| Spring 1968 | First delivery of production CH-47C | 3, p. 174 |
| September 1968 | First deployment of CH-47C in Vietnam | 36, p. 34 |

CH-53 SEA STALLION (Sikorsky S-65A)

Antecedents to the S-65A: The S-56 was a new design (Sikorsky's first twin-engine helicopter) built to meet USMC requirements for an assault transport capable of carrying about 26 troops. It retained the classic Sikorsky layout of a single main rotor and anti-torque tail rotor. The new features included placing the two engines in pods on each side of the fuselage (leaving the cabin area for load carrying). The main legs of the under-carriage were retractable into the engine pods and clam-shell doors below the flight deck provided direct access to the cabin. Empty weight was about 20,800 lb and gross weight was about 31,000 lb. It used two Pratt and Whitney R-2800 engines and could carry 20 troops or 1900 cu ft of cargo.

| Date | Event | Source |
|---|---|---|
| 9 May 1951 | USN issues prototype contract | 2, p. 87;<br>3, p. 135 |
| 18 December 1953 | First prototype flight | 2, p. 87;<br>3, p. 135 |
| 25 October 1955 | First production model flight | 2, p. 87 |
| 26 July 1956 | First operational delivery to USN | 2, p. 87;<br>3, p. 136 |

The U.S. Army also bought some S-56s

The S-60 was Sikorsky's first attempt at building a flying crane helicopter. The design work was jointly funded by the company and the USN. To speed development and minimize flight testing, the S-60 used the power plant, rotor, and transmission systems from the S-56. As with the S-56, the Pratt and Whitney R-2800 engines were mounted in outrigged pods into which the wheels could be partially retracted. The fuselage was a boom with a cockpit at the front end, the main rotor mounting in the middle and the tail rotor at the back end. The payload of up to six tons could be attached under the boom between the wheels like a module or could be slung from a hoist.

| Date | Event | Source |
|---|---|---|
| May 1958 | Design work begins | 2, p. 97 |
| 25 March 1959 | First prototype flight | 2, p. 97 |
| 3 April 1961 | S-60 prototype destroyed in crash | 2, p. 97 |

Work on the S-64 had begun before the S-60 crash and was a company-funded development of a turbine-powered variant to the S-60. It had a similar fuselage and rotor system but used a six-bladed rather than a four-bladed main rotor. It also differed in that its two 4050 shp JFTD-12A shaft turbines were mounted side by side on top of the fuselage boom immediately below the rotor. It also had a new undercarriage design with "kneeling" capability. Its personnel and cargo pod could carry 68 troops or 48 stretchers or 55 airline passengers. Its empty weight was about 17,200 lb and its gross weight was about 38,000 lb. For related dates, see CH-54A.

The S-65 incorporated parts from the S-64, but its fuselage resembled a scaled-up version of the S-61R although it was flat-bottomed, which differed from the S-61R's boat hull. The watertight hull had sponsons amidships that housed the fuel tanks and main undercarriage. The rotors, transmission, and other dynamic components were taken from the S-64. However, the S-65 had a rear-loading ramp and could carry about 8,000 lb internally or 13,000 lb externally. Standard power plant was the T64-GE-6 shaft turbine.

CH-53 SEA STALLION (Sikorsky S-65A)--continued

| Date | Event | Source |
|---|---|---|
| 27 August 1962 | USN announces that Sikorsky has been selected as the USMC heavy assault helicopter | 6, p. 456; 10, p. 297; 11, p. 250 |
| August 1962 | Initial production contract awarded for the CH-53A | 1/Part 1 |
| 14 October 1964 | First prototype flight | 6, p. 456; 10, p. 297; 20, p. 37; |
| June 1966 | First delivery of CH-53A | 12 |
| September 1966 | USAF orders eight HH-53Bs. The HH-53B was similar to the CH-53A. It was used by the USAF Aerospace Rescue and Recovery Service. It was armed and had jettisonable fuel tanks, retractable refuelling probe, and a rescue hoist. | 6, p. 457; 11, p. 350 |
| January 1967 | First deployment of CH-53A in Vietnam | 11, p. 350 |
| 15 March 1967 | First flight of production HH-53B | 6, p. 457; 11, p. 350; 21, p. 67; 24, p. 122 |
| June 1967 | First delivery of HH-53B | 6, p. 457; 11, p. 250; 24, p. 122; 36, p. 71 |
| 30 August 1968 | First delivery to USAF of HH-53C, an improved version of the HH-53B | 6, p. 457; 24, p. 122; 36, p. 71 |
| 3 March 1969 | First delivery to USMC of CH-53D, an improved version of the CH-53A | 6, p. 457; 36, p. 71 |
| 27 October 1970 | USN announces plans to form mine countermeasures squadrons; the unit was formed using 15 CH-53As borrowed from the USMC and redesignated RH-53A | 6, p. 458 |
| 31 January 1972 | Last delivery of CH-53D. (A total of 265 were delivered to the USMC.) | 6, p. 457; 36, p. 71 |
| February 1972 | Sikorsky announces receipt of USN award of an advanced procurement authorization for 30 RH-53Ds, an improved version of the RH-53A | 6, p. 458 |
| 27 October 1972 | First prototype flight of the RH-53D | 6, p. 458 |
| September 1973 | First delivery of the RH-53D | 6, p. 458; 36, p. 71 |
| 1 March 1974 | First YCH-53E prototype flight. The CH-53E was developed for the USMC and USN as a utility and tactical support helicopter. It is a three-engine development of the S-65A and has a seven-bladed main rotor with titanium blades, an uprated transmission, modified tail surfaces, and other airframe and equipment improvements | 36, p. 72 |
| Early 1976 | Flight testing of preproduction models begin | 36, p. 72 |
| May 1976 | Structural demonstration tests begin | 36, p. 72 |
| 28 February 1978 | First production order for six CH-53Es received from USMC | 36, p. 72 |

CH-54 TARHE (Sikorsky S-64A)

Background: See CH-53.

| Date | Event | Source |
|---|---|---|
| 9 May 1962 | First S-64A prototype flight | 2, p. 97; 10, p. 296; 8, p. 451; 36, p. 70 |
| June 1963 | U.S. Army orders six S-64As to test the heavy lift concept for increasing mobility under battlefield conditions (designated YCH-54A) | 8, p. 451; 10, p. 296; 25, p. 324; 36, p. 70 |
| 30 June 1964 | U.S. Army accepts first YCH-54A | 10, p. 296; 22, p. 57; 36, p. 70 |
| October 1964 | First delivery of test vehicle | 10, p. 296 |
| Late 1964 | First operational delivery to U.S. Army | 7, p. 403 |
| 3 July 1965 | S-64A receives FAA Type Approval | 6, p. 455 |
| January 1968 | First delivery of skycrane modular van accepted by government | 23, p. 23 |
| 4 July 1968 | Sikorsky announces receipt of U.S. Army contract to increase payload capacity of the CH-54A. Required design improvements to the engine, gearbox, rotor head and structure. The Army also wanted improved altitude and hot weather operating capabilities (designated CH-54B) | 6, p. 455 |
| 1969 | First operational delivery of CH-54B | 6, p. 455 |

## HH-43, UH-43, OH-43 HUSKIE (Kaman K-600/600-3)

Kaman had developed several predecessors to the K-600 during the late 1940s and early 1950s. The USN bought one K-225 for evaluation in March 1950 (the K-225 had received FAA Type Approval September 16, 1949). In June 1950, the USN purchased another K-225. These tests led to a USN contract to develop the K-240 and on 5 September 1950, the USN ordered 29 K-240 helicopters (first delivery was November 1951). The K-240 was the immediate predecessor to the K-600.

| Date | Event | Source |
|---|---|---|
| June 26, 1950 | USN announces K-600 winner of a design competition for a USMC liaison and general utility helicopter. The contract was for "off the drawing board" development, designated OH-43D | 2, p. 53; 3, p. 162 |
| 27 September 1956 | First prototype flight using an XT53 engine in a modified OH-43D airframe (predecessor to the K-600-3) | 2, p. 51; 3, p. 162; 9, p. 249; 34, p. 249 |
| 27 December 1956 | USN orders 24 UH-43C (the K-600) for general utility duties | 2, p. 53; 3, p. 162 |
| 1957 | USAF conducts evaluation for local crash rescue. It found no acceptable design, but ordered the K-600 as an interim measure until the K-600-3 was ready | 2, p. 51 |
| April 1958 | First delivery of OH-43D to USMC | 3, p. 162 |
| May 1958 | First delivery of production UH-43C to USN | 2, p. 53 |
| 1 August 1958 | First operational delivery of UH-43C | 2, p. 53 |
| 19 September 1958 | First flight of production USAF HH-43A (differed from USMC and USN K-600s only in its rescue equipment) | 3, p. 162; 2, p. 51 |
| November 1958 | First delivery of HH-43A to USAF. | 2, p. 51 |
| 13 December 1958 | First flight of K-600-3 prototype (which became the HH-43B) | 3, p. 162; 2, p. 51; 34, p. 249 |
| August 1964 | First flight of the production HH-43F. (This was an improved version of the HH-43B, with greater power, increased fuel capacity, and other minor changes. It was designed for operations where optimum altitude performance under hot-weather conditions was required.) | 24, p. 122; 34, p. 249 |

## HH-52A (Sikorsky S-62A)

Based on the S-55, the S-62A had identical main and tail rotors, transmission systems and other dynamic components to this predecessor. The main difference was that it used turbine rather than piston engines. It had a different fuselage design for fully amphibious operations (flying boat hull and undercarriage wheels that were semiretractable within two outrigged stabilizing floats. The single GE shaft turbine engine was mounted above the main cabin, which could accommodate a two-person crew and 10-12 passengers.

| Date | Event | Source |
|---|---|---|
| Late 1957 | Sikorsky begins design work on S-62 | 3, p. 150 |
| 14 May 1958 | First prototype flight | 10, p. 296; 36, p. 69 |
| 30 June 1960 | S-62A receives FAA Type Approval | 3, p. 150; 10, p. 296 |
| 6 February 1962 | After service testing the S-62A, the USN orders four production models for the USCG | 3, p. 150; 2, p. 95 |
| January 1963 | First production delivery of HH-52A | 10, p. 296 |

OH-6 CAYUSE (Hughes Model 369)

| Date | Event | Source |
|---|---|---|
| 1960 | DoD issues Technical Specification No. 153 to initiate design competition for a light observation helicopter (lightweight, four-place helicopter with Allison T63 gas turbine engine capable of carrying a 400 lb payload plus pilot and full fuel load. Minimum speed was to be 110 kt) | 3, p. 156; 2, p. 46 |
| October 1960 | RFP issued | 12 |
| 19 May 1961 | U.S. Army announces Bell and Hiller selected to build prototypes<br><br>(Twelve companies had submitted 22 designs in the LOH competition) | 6, p. 359 |
| June 1961 | Hughes is added to the list of winners; all three companies to build five prototypes each | 6, p. 359 |
| 8 December 1962 | First prototype flight, Bell Model 206 | 2, p. 14; 12 |
| 26 January 1963 | First prototype flight, Hiller Model 1100 | 2, p. 46; 11, p. 254 |
| 27 February 1963 | First prototype flight, Hughes Model 369 | 3, p. 156; 9, p. 245; 11, p. 275; 36, p. 42 |
| November 1963 | U.S. Army selection trials begin | 3, p. 157 |
| 26 May 1965 | U.S. Army selects Hughes 369 as LOH. Initial order for 714 helicopters issued, designated OH-6 Cayuse. | 9, p. 245; 11, p. 275; 26, p. 20 |
| September 1966 | First delivery of production OH-6 | 3, p. 157 |

## OH-23 RAVEN (Hiller UH-12)

During the late 1940s, Hiller designed a light single-engine helicopter that subsequently evolved into the UH-12 prototype.

| Date | Event | Source |
|---|---|---|
| 14 October 1948 | UH-12 receives FAA Type Approval | 3, p. 121 |
| 1950 | Modifications to the rotor blades and use of a larger engine became the UH-12A model | 3, p. 121 |
| May 1950 | USN and the U.S. Army each procure one UH-12A for evaluation | 2, p. 41 |
| 8 May 1950 | UH-12A receives FAA Type Approval | 2, p. 41 |
| August 1950 | Service evaluations completed | 2, p. 41 |
| 1950 | USN orders small number of UH-12As as trainers, designated HTE-1 | 2, p. 41 |
| 1950 | U.S. Army orders about 100 UH-12As as the OH-23 Raven | 2, p. 41 |
| 1951 | Deliveries to USN and U.S. Army begin | 2, p. 41 |
| 1951 | After operational experience in Korea, the U.S. Army requested certain modifications to improve performance under wartime conditions. This led to the development of the UH-12B | 2, p. 41 |
| 2 November 1951 | UH-12B receives FAA Type Approval | 2, p. 41 |
| Date NA | U.S. Army orders UH-12B as OH-23B; Eventually bought about 273 OH-23Bs most of which were assigned to the Primary Helicopter School | 2, p. 41 |
| 1955 | Major design changes lead to the UH-12C | 3, p. 122 |
| 12 December 1955 | UH-12C receives FAA Type Approval | 3, p 122 |
| 1956 | U.S. Army begins receiving UH-12C designated OH-23C | 3, p. 122 |
| 3 April 1956 | First prototype flight of UH-12D which was an improved version of the UH-12C | 3, p. 122; 2, p. 42 |
| December 1957 | First delivery of UH-12D to U.S. Army, designated OH-23D | 2, p. 42 |
| 23 December 1957 | UH-12D receives FAA Type Approval. | 2, p. 42 |
| 6 January 1959 | UH-12E receives FAA Type Approval (it was an improved version of the UH-12D) | 2, p. 42 |
| 1963 | U.S. Army orders UH-12E as the OH-23G with the last order for OH-23Ds specifying that they be upgraded to the 23G configuration | 10, p. 232 |

## OH-58 KIOWA (Bell Model 206A)

Bell developed the Model 206A JetRanger as a commercial venture after losing the original LOH competition to Hughes (see OH-6). The Model 206A was based heavily on Bell's LOH entry.

| Date | Event | Source |
|---|---|---|
| July 1965 | Company-funded construction of the Model 206A prototype begins (two months after Hughes won the LOH competition) | 11, p. 207 |
| 10 January 1966 | Bell Model 206A first prototype flight | 3, p. 158; 11, p. 207 |
| 20 October 1966 | Model 206A receives FAA Type Approval | 3, p. 158; 11, p. 207 |
| August 1967 | U S Army reopens LOH competition | 12; 27, p 15 |
| February 1968 | USN selects Bell 206A JetRanger for trainer, designated TH-57A SeaRanger | 29, p. 17 |
| 8 March 1968 | U.S. Army names Bell winner of reopened LOH competition and orders first increment of planned 2,200 helicopter buy, designated OH-58A | 6, p. 268; 28, p. 326 |
| October 1968 | First delivery of TH-57A to USN | 12 |
| 23 May 1969 | First delivery of OH-58A Kiowa | 12; 6, p. 268; 36, p. 24 |
| August 1969 | First deployment of OH-58A in Vietnam | 6, p. 268; 36, p. 24 |
| 30 June 1976 | U.S. Army grants "development qualification contract" to Bell to convert OH-58As to an improved standard, designated OH-58C | 7, p. 239 |

SH-3 SEA KING (Sikorsky S-61A/B/F)

| Date | Event | Source |
|---|---|---|
| 23 September 1957 | USN awards contract for development of an amphibious anti-submarine helicopter | 6, p. 452; 10, p. 294; 36, p. 65 |
| 11 March 1959 | First prototype flight of the SH-3A (first known as the HSS-2) | 2, p. 91; 6, p. 452; 10, p. 294 |
| 1960 | First delivery of prototype for service testing (seven had been ordered) | 3, p. 148 |
| 8 February 1961 | Navy Board of Inspection and Survey trials begin | 10, p. 294 |
| September 1961 | First fleet delivery | 6, p. 452; 36, p. 65 |
| April 1964 | USN contract announced for conversion of SH-3As for mine countermeasures duty (carry, stream, tow, and retrieve a variety of mine countermeasures gear), designated RH-3A | 6, p. 453; 10, p. 293 |
| 1965 | Deliveries begin of RH-3A conversions | 6, p. 453 |
| June 1966 | Deliveries begin of uprated SH-3As, designated SH-3D | 6, p. 453; 11, p. 346 |
| 10 June 1971 | USN announces contract to convert all SH-3A, SH-3D, and SH-3G helicopters to an improved configuration, designated SH-3H (had new sonar equipment for anti-submarine warfare duties and new radar for anti-missile defense) | 6, p. 453 |

## SH-34 SEABAT, CH-34 CHOCTAW, UH-34 SEAHORSE (Sikorsky S-58)

The S-55 was the forerunner of the S-58 and the S-62. Before this model, Sikorsky had built primarily small single-seat or two-seater helicopters, mainly for the USAAF and USN during World War II. The layout of the S-55 was similar to earlier Sikorsky efforts with the single main rotor and a tail boom carrying the tail rotor. The S-55 differed in its larger size and in the location of the engine in the nose of the vehicle with the transmission shaft running up through the center of the cockpit to the rotor head, leaving the main cabin area free for cargo.

| Date | Event | Source |
|---|---|---|
| 1948 | Five S-55 prototypes ordered | 2, p. 89 |
| 10 November 1949 | First S-55 prototype flight | 2, p. 89; 34, p. 254 |
| 1951 | USAF issues first contract for production S-55s | 2, p. 89 |
| | USAF eventually bought over 450 S-55s | |
| 28 April 1950 | USN places first production order for S-55 | 2, p. 89 |
| 27 December 1950 | First operational delivery to Utility Squadron HU-2 | 2, p. 89 |
| | USN eventually bought almost 200 S-55s | |
| August 1950 | USMC adopts S-55 as assault transport with self-sealing fuel tanks | 2, p. 89 |
| 2 April 1951 | First delivery of S-55 to USMC | 2, p. 89 |

The S-58 was designed specifically for anti-submarine warfare duties with the USN. The S-55 had been used but lacked sufficient load-carrying ability and range. The S-58 is larger but retained the S-55's general layout. It has a larger engine and a four-bladed rather than a three-bladed main rotor that can be folded for ship-board storage. It could accommodate twice as many passengers as the S-55.

| Date | Event | Source |
|---|---|---|
| 30 June 1952 | USN contracts for S-58 prototype | 2, p. 89; 36, p. 64 |
| 8 March 1954 | First S-58 prototype flight | 10, p. 292; 2, p. 89; 35, p. 173; 34, p. 255 |
| | Preliminary production contracts had already been issued for the SH-34G Seabat by the time the first S-58 prototype had flown | 2, p. 89 |
| 20 September 1954 | First production SH-34G flight | 2, p. 89 |
| August 1955 | First operational delivery to HS-3 Squadron | 2, p. 89; 3, p. 138 |

The USMC bought S-58s as utility transports (UH-34D Seahorse). The first USMC production order was 15 October 1954 with the first operational delivery occurring on 5 February 1957. The U.S. Army also purchased S-58s (CH-34A Choctaw). The first Army production order was placed in 1953 and the first delivery was in April 1955.

TH-55A OSAGE (Hughes Model 269A-1)

| Date | Event | Source |
|---|---|---|
| 1954-1960 | Hughes commissioned an extensive market research program that persuaded management of a substantial market potential for light helicopters | 2, p. 49 |
| September 1955 | Hughes begins development of a lightweight helicopter on its own for the commercial market | 2, p. 49; 10, p. 236 |
| October 1956 | First prototype flight of Model 269 | 2, p. 49; 10, p. 236; 36, p. 41 |
| 1958 | U.S. Army orders five Model 269As for tests as a light helicopter trainer | 2, p. 49 |
| July 1960 | Hughes decides on commercial production of the Model 269A (an improved version of the Model 269) | 2, p. 49 |
| 25 October 1961 | First commercial delivery of production Model 269A | 2, p. 49; 36, p. 41 |
| Mid-1964 | U.S. Army selects Model 269A-1 as a light helicopter trainer | 8, p. 362 |

UH-1 IROQUOIS (Bell Models 204/205/212)

| Date | Event | Source |
|---|---|---|
| 1954 | U.S. Army initiates design competition for a helicopter to perform general utility duties, front-line casualty evacuation, and instrument flight training | 12 |
| June 1955 | Bell wins design competition. U.S. Army orders three prototypes | 2, p. 11; 12; 34, p. 244 |
| 22 October 1956 | First prototype flight of the UH-1 (Model 204) | 2, p. 11 |
| 1957 | U.S. Army orders six UH-1s for service testing | 2, p. 11 |
| February 1958 | First service test flight of UH-1 | 2, p. 11 |
| Early 1958 | U.S. Army places first production order for the UH-1A. (The UH-1A was the first large-scale production version of the Iroquois series. It was generally similar to the UH-1 prototypes with only minor changes.) | 2, p. 11 |
| September 1958 | First flight of production UH-1A | 1/Part 2 |
| 1959 | U.S. Army requests development of improved version of the UH-1A | 2, p. 12 |
| June 1959 | Development of improved version begins | 2, p. 12 |
| 30 June 1959 | First delivery of production UH-1A | 2, p. 11; 12; 36, p.29 |
| 1960 | First deployment of the UH-1A | 2, p. 11 |
| 1960 | First prototype flight of UH-1B | 2, p. 12 |
| July 1960 | U.S. Army announces contract for seven test models of an improved Iroquois with larger carrying capacity and longer range at faster speeds, designated the UH-1D (Bell Model 205) | 2, p. 12; 6, p. 266; 11, p. 208 |
| December 1960 | U.S. Army issues first production order for the UH-1B | 2, p. 12 |
| March 1961 | First production delivery of UH-1B | 2, p. 12; 10, p. 182 |
| 16 August 1961 | First prototype flight of UH-1D | 2, p. 12; 6, p. 266; 11, p. 208 |
| 1961 | U.S. Army orders production of UH-1D | 2, p. 12 |
| March 1962 | Bell wins USMC design competition for an assault support helicopter with a variant of the UH-1B (differing mainly in equipment), designated UH-1E | 2, p. 13; 6, p. 266 |
| March 1962 | U.S. Army flight testing of UH-1D begins at Edwards AFB | 11, p. 209 |
| February 1963 | First flight of production UH-1E | 10, p. 182; 11, p. 209 |
| May 1963 | First delivery of production UH-1D | 2, p. 12 |
| June 1963 | Bell wins USAF design competition for missile site support helicopter with a variant to the UH-1B, designated UH-1F | 30, p. 55; 10, p. 182 |

UH-1 IROQUOIS (Bell Models 204/205/212)--continued

| Date | Event | Source |
|---|---|---|
| June 1963 | USAF first production order for 25 UH-1Fs | 6, p. 266; 11, p. 209 |
| 9 August 1963 | First deployment of UH-1D (11th Air Assault Division, Ft. Benning) | 6, p. 266; 36, p. 30; 10, p. 182; 11, p. 209 |
| 20 February 1964 | First test flight of UH-1F | 31, p. 21; 24, p. 121; 6, p. 266; 10, p. 182 |
| 21 February 1964 | First operational delivery of UH-IE (Marine Air Group 26, New River, NC) | 6, p. 266; 10, p. 182; 11, p. 209 |
| September 1964 | First production delivery of UH-1F (4486th Test Squadron, Eglin AFB) | 6, p. 266; 10, p. 182; 24, p. 121; 11, p. 209 |
| September 1967 | First production delivery of the UH-1H (Bell Model 205A-1, which was similar to the UH-1D with a larger engine and was ordered as replacement to the UH-1D | 7, p. 237; 36, p. 30 |
| 1 May 1968 | Bell announces receipt of a development of a contract from the Canadian government for a twin-engine version of the UH-1H (uses the UH-1H airframe but has twin turbines and advanced avionics), designated UH-1N (Bell Model 212) | 6, p. 271; 24, p. 121 |
| 19 September 1969 | Bell announces production order from Canadian government for the UH-1N | 6, p. 271; 24, p. 121 |
| September 1969 | USAF orders 79 UH-1Ns, USN orders 40 UH-1Ns, and USMC orders 22 UH-1Ns | 6, p. 271; 24, p. 121 |
| September 1970 | First delivery of UH-IN to USAF | 6, p. 271 |
| 4 November 1970 | USAF issues fixed-price contract for 30 local base rescue helicopters, designated HH-1H (the same as the UH-1H Bell Model 205, but with different equipment) | 6, p. 266; 24, p. 121 |
| April 1971 | First delivery of UH-1N to USMC | 6, p. 271 |
| Late 1971 | First delivery of UH-1N to USN | 6, p. 271 |
| 1972 | First delivery of HH-1H to USAF | 24, p. 121 |

UH-2 SEASPRITE

| Date | Event | Source |
|---|---|---|
| 1956 | Kaman wins USN design competition for a fast long-range utility helicopter. Its primary role was search and rescue. Other duties included all-weather carrier guard duty, gunfire observation, courier duty, personnel transfer, reconnaissance, tactical air controller, and medical evacuation. It was to have emergency flotation capability. | 2, p. 55 |
| 29 November 1957 | USN order four test models and 12 production models, designated UH-2 | 2, p. 55 |
| 2 July 1959 | First test flight | 2, p. 55; 10, p. 241; 34, p. 250; 36, p. 45 |
| 18 December 1962 | First delivery of production version, designated UH-2A | 2, p. 55; 9, p. 250; 10, p. 241; 11, p. 278; 36, p. 45 |
| 4 June 1963 | First shipboard service (aboard the USS Independence) | 3, p. 142; 10, p. 241; 11, p. 278 |
| 8 August 1963 | First shipboard delivery of the UH-2B (aboard the USS Albany). It had been developed from the UH-2A for VFR conditions and differed only in its electronic navigational equipment | 6, p. 364; 3, p. 142; 10, p. 241; 11, p. 278; 36, p. 45 |
| 2 January 1964 | Kaman announces receipt of USN contract to add special rescue equipment to the UH-2A and UH-2B. The converted model was designated UH-2C | 10, p. 241; 11, p. 278 |
| March 1965 | First conversion to the UH-2C configuration completed | 3, p. 142 |
| August 1967 | Deliveries of converted UH-2C models begin | 6, p. 364; 8, p. 366 |
| February 1970 | First operational delivery of the HH-2D, an armed and armored twin-engine development of the UH-2C. Its primary mission was the search and rescue of downed pilots | 6, p. 364 |
| October 1970 | USN awards Kaman a contract for modifying 10 HH-2Ds to the interim LAMPS (Light Airborne Multi-Purpose System) configuration for anti-submarine warfare and anti-ship missile defense duties, designated the SH-2D | 6, p. 364 |
| | LAMPS modifications involved (1) installation of Canadian Marconi LN 66 high-power surface radar in a glassfibre honeycomb dome under the chin; (2) ASQ-81 MAD deployed by winch from a pylon on the starboard side of the fuselage; (3) 15 AN, p. SSQ-47 active or AN, p. SSQ-41 passive sonobuoys launched by a small explosive charge from a removable rack on the port side; (4) ALR-54 electronic support measure; (5) 8 Mk 25 marine | |

UH-2 SEASPRITE--continued

| Date | Event | Source |
|---|---|---|
| | flares, p. smoke markers; (6) data link; (7) tactical navigational system and associated communications and control units, recorders, displays and antennae; (8) auxiliary fuel tanks hardened for launching Mk 44 and Mk 46 ASW homing torpedoes. | |
| 16 March 1971 | First flight of the SH-2D | 6, p. 364; 36, p. 45 |
| July 1971 | Additional 10 conversions ordered | 6, p. 364 |
| 7 December 1971 | First operational deployment | 6, p. 364; 36, p. 45 |
| March 1972 | All 20 conversions completed | 6, p. 364 |
| February 1973 | First USN contract for SH-2F LAMPS. This was an improved version of the SH-2D. It had a new rotor developed under joint USN-Kaman funding that increased performance in terms of reliability and maintenance through elimination of most of the vibration. It also had a shorter wheelbase, stronger landing gear, improved navigational and communications equipment and new engines. The USN planned to convert all HH-2s and SH-2Ds to the SH-2F configuration. | 6, p. 364 |
| May 1973 | First delivery of converted SH-2F | 6, p. 364; 7, p. 322 |
| 11 September 1973 | First operational deployment of the SH-2F | 6, p. 364; 7, p. 322 |

## UH-60 (UTTAS) BLACKHAWK (Sikorsky S-70)

Although improved performance (over that of the UH-1 series) was one goal of the U.S. Army's Utility Tactical Transport Aircraft System (UTTAS), more important was minimizing lifetime cost by enhancing reliability, availability, and maintainability (RAM). Believing that reliable RAM statistics could be generated only by using full-scale production prototypes, and believing that performance requirements could be met with available low-risk technology, the service initiated the program as a full-scale development; the UTTAS program began with DSARC II and ended with a production decision. To generate statistically significant RAM figures before making a production commitment, the Army hoped to take six full-scale prototypes from each of two competing contractors through a total of 11,360 flight test hours. Although subsequently abbreviated by the Congress, the approved program still involved several thousand hours of aircraft and engine testing over two years.

| Date | Event | Source |
|---|---|---|
| July 1968 | Concept formulation | 12 |
| August 1968 | First study contracts awarded | 12 |
| 22 June 1971 | Blackhawk approved for full-scale development. (DEPSECDEF, on the DSARC recommendation, signs Decision Coordinating Paper No. 13.) | 40, p. 3 |
| July 1971 | Engine RFP issued | 5, p. 32 |
| 5 January 1972 | Airframe RFP issued | 5, p. 32 |
| 6 March 1972 | Engine development contract awarded to General Electric Company | 40, p. 3 |
| 31 March 1972 | Airframe proposals received | 40, p. 3 |
| 30 August 1972 | Airframe prototype development contracts awarded to Sikorsky and Boeing-Vertol | 5, p. 32; 36, p. 74; 40, p. 3 |
| 17 October 1974 | Sikorsky first prototype flight | 5, p. 21; 32, p. 22; 36, p. 74 |
| 29 November 1974 | Boeing-Vertol first prototype flight | 5, p. 21; 33, p. 21 |
| 20 March 1976 | Three prototypes from each contractor accepted by the U.S. Army | 40, p. 6 |
| March 1976 | Government fly-off begins | 40, p. 6; 36, p. 74 |
| 31 August 1976 | Sikorsky ground test vehicle delivered | 40, p. 6 |
| 1 September 1976 | Boeing-Vertol ground test vehicle delivered | 40, p. 6 |
| 23 December 1976 | Sikorsky wins production contract with 12 helicopters ordered. Also received option to produce up to 330 more UH-60s over three years | 5, p. 41; 43, p. 4; 36, p. 74 |
| 23 December 1976 | GE awarded engine production contract for 53 T-700 engines | 36, p. 74; 40, p. 6 |
| 1 September 1977 | S-70 elected by USN as the SH-60B LAMPS III helicopter to replace the SH-2F Seasprite. It differs from the UTTAS in having automatic rotor blade and tail | 36, p. 74 |

UH-60 (UTTAS) BLACKHAWK (Sikorsky S-70)--continued

| Date | Event | Source |
| --- | --- | --- |
| | rotor pylon folding, movement of the tail wheel further forward, MAD, and surface search radar. It can carry two Mk 46 torpedoes | |
| 28 February 1978 | Development contract for five prototype SH-60B's received | 36, p. 74 |
| October 1978 | First flight of production UH-60A | 39, p. 22 |
| 31 October 1978 | First production delivery of UH-60A UTTAS to U.S. Army | 40, p. 6 |
| 11 June 1979 | Flight Development Test and Evaluation of UH-60A begins | 40, p. 6 |
| 12 December 1979 | First prototype flight of SH-60B Seahawk | 38, p. 19 |

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# Appendix C

## A COMPENDIUM OF MISSILE PROGRAM MILESTONES

CONTENTS



Unless other sources are specifically cited, all data in this appendix were derived from the files of the Historical Office, Aeronautical Systems Division of AFSC, Wright-Patterson Air Force Base, Ohio.

GAR-1 FALCON

| Date | Event |
|---|---|
| YGAR-1 | |
| 7 November 1947 | Requirement established |
| March 1947 | Project initiated--study and development program for a small supersonic air-to-air guided rocket |
| June 1947 | Project reduced to the development of the semi-active radar seeker because of budget limitations |
| March 1948 (FSD start) | Project reinstated as a complete missile development |
| February 1949 | Hq USAF directed that development of tne fighter-launched guided aircraft rocket for offensive use have priority over the bomber launched missile development |
| May 1951 | First YGAR-1 air launch |
| January 1954 | Service procurement of YGAR |
| November 1954 | First production GAR-1s delivered |
| XGAR-1A | |
| 30 March 1955 | GOR 84 issued |
| 12 May 1955 | First XGAR-1A missile was air-launched |
| November 1956 | Production of GAR-1 missiles terminated |

IM-99A BOMARC

| Date | Event |
|---|---|
| 24 November 1949 | Study begins under Hq USAF authority |
| January 1950(a) | Boeing Airplane Company and the Aeronautical Research Center of the University of Michigan requested by Air Materiel Command to make a cooperativc study |
| May 1950 | Study completed; Boeing authorized to begin preliminary design |
| 22 September 1950 | Military characteristics for missile are published |
| 31 December 1950(a) | Boeing's preliminary design work completed |
| 12 January 1951(a) (FSD start) | AF contract authorizing development |
| 10 September 1952(a) | First flight test |
| August 1954(a) | First successful flight (6th missile) |
| 30 April 1959 | Initial delivery date |
| 1 September 1959(b) | Operational date |
| September 1959 | Category II test program held in abeyance because of inadequate test results |
| February 1960 | Testing resumed |
| September 1960 | Category II tests successfully completed |

(a) Development of USAF XIM-99A Weapon System, Jan. 1951-Mar. 1959, Boeing Aircraft Co.
(b) Charles E. Minihan, "The BOMARC Weapon System," Air University Review, Vol. 13, No. 4, Summer 1962.

TM-76B MACE

| Date | Event |
|---|---|
| 12 October 1954 | GOR 37 issued |
| 19 January 1955 | System requirement No. 15 |
| Late 1955 | Funds allocated and contract let to Martin |
| 27 January 1956 (FSD start) | Development contract |
| 1956 | Active R&D |
| 1957 | Funds severely cut |
| 7 August 1959 | Production contract |
| 6 February 1958 | First inertial guidance flight |
| November 1960 | First production delivery |

AGM-69A SRAM

| Date | Event |
|---|---|
| 24 April 1963 | Hq USAF issued ADO 51 for all-weather, tactical air-to-surface missile |
| 1 August 1963(a) | USAF published a draft SOR on SRAM |
| 18 March 1964 | SOR 12 issued |
| 23 March 1965(b) | Secretary McNamara approved the initial development of SRAM |
| 29 April 1965 | Hq USAF issued System Definition Directive ZAGM-69A, which formally authorized initiation of project definition |
| 28 July 1965 | Hq USAF approved release of RFP to industry for Phase I |
| 30 July 1965 | RFP released |
| 30 August 1965 | AF received SRAM definition proposals from five contractors |
| 2 November 1965 | AF announced that Martin-Marietta Corp. and Boeing had won Phase I competition |
| 2 September 1966 | Contractor completed Phase I tasks |
| 31 October 1966 (FSD start) | Secretary of the AF announced Boeing as Phase II contractor |
| 7 November 1966 | Boeing awarded propulsion contract to Lockheed Propulsion Co. |
| 21 November 1966 | Acquisition contract awarded to Boeing |
| 6 December 1967 | First dummy missile dropped |
| 1 April 1968 | SecDef approved Development Concept Paper 51 for the AGM-69A program |
| 1 August 1968 | AF begins FB-111 SRAM Category I flight testing |
| July 1969 | First powered launch |
| 9 July 1969 | Contractor launched first SRAM from a B-52 carrier |
| 26 January 1970 | DoD approved 1,900 missile procurement program on an incremental basis |
| June 1970 | Long lead production authorized |
| 5 December 1970 | DoD approved SRAM production |
| 12 January 1971(b) | Hq USAF awarded a contract to Boeing for SRAM production |
| 1 March 1972(b) | First production SRAM delivered to SAC |
| August 1972 | AF activated first B-52 SRAM squadron |
| 12 January 1973 | Procurement reduced from 1,900 to 1,500 |

(a) "Chronology of Events Related to the Advanced Manned Strategic Aircraft Program, 1954-1964" (unpublished USAF working paper).
(b) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

AGM-65A/B MAVERICK

| Date | Event |
|---|---|
| 15 July 1964 | SOR 215 issued |
| 7 June 1966 | Concept formulation started |
| 10 July 1968 (FSD start) | Contract definition completed contract awarded |
| 3 September 1968 | DCP approved |
| 3 March 1969 | Preliminary design review |
| 1 August 1969 | Category I flight test begins |
| 15 May 1970 | Critical design review |
| 22 December 1970 | Preliminary configuration inspection |
| 16 January 1971 | Category II flight test begins |
| June 1971 | DSARC III |
| 26 November 1971 | Category II flight test ends |
| 1 September 1972 | Engineering development ends |
| December 1972 | Delivery date of first production missile |
| 15 February 1973 | IOC |
| 24 July 1973 | FACI |

GAM-87 SKYBOLT

| Date | Event |
|---|---|
| July 1957 | RFP for missile to be launched from B-52; ballistic mode considered, but rejected because of long development time |
| October 1957 | System requirement #187, calling for an advanced air-to-air missile |
| January 1958 | One-year demonstration program started |
| March 1958 | Contract to Martin for 4-missile flight test. |
| July 1958 | Range goal of test vehicles extended, more test items added to Martin contract |
| December 1958 | Demonstration program completed; possibility of air-launching a ballistic missile proven |
| January 1959 | GOR #177 issued, development program for operational system authorized, RFP issued |
| May 1959 | Source Selection announced; DDR&E directed that initial work be limited to design studies |
| July-October 1959 | Major subcontractors selected |
| February 1960 (FSD start) | OSD authorizes full scale development |
| December 1960 | Development funds reduced, program stretched |
| April 1962 | First powered flight |
| December 1962 | Program canceled |

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GAM-72 QUAIL

| Date | Event |
|---|---|
| 13 October 1952(a) | SAC requirement forwarded to Hq USAF |
| March 1953 | GOR issued |
| October 1953 | Development Directive authorized ARDC to start full development program |
| November 1954 | Source selection forwarded to Hq USAF |
| April 1955 (FSD start) | Development contracts awarded for Phase I (to mockup) |
| September 1955 | Funding cut |
| 18 January 1956(b) | Hq USAF issued GOR #139 for a short-range, air-launched missile, later designated Quail |
| 1 February 1956(b) | McDonnell selected for Phase II development |
| November 1957 | First glide launch |
| August 1958 | First powered flight |
| 31 December 1958(b) | Letter contract for initial production lot awarded McDonnell |
| 1 March 1960(b) | First successful powered flight of a prototype Quail missile |
| 13 September 1960(b) | First production Quail missiles delivered |
| 1 February 1961(b) | First squadron operational |

(a) From Snark to SRAM: A Pictorial History of Strategic Air Command Missiles, Office of the Historian, Hq Strategic Air Command, 21 March 1976.
(b) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

GAM-77 HOUND DOG

| Date | Event |
|---|---|
| 15 March 1956(a) | GOR 148 issued, calling for B-52 ASM; major contenders were Rascal and Regulus II |
| June 1956 | Proposals submitted by Bell and Vought for System 131A |
| September 1956 | System 131A canceled |
| March 1957 | North American submits initial proposal for a lightweight ASM |
| April 1957 | Draft revision of GOR #148 issued, emphasizing lightweight missile |
| June 1957 | New system specs issued, system designated 131B |
| July 1957 | Proposals submitted by firms |
| July 1957 | Navaho program canceled |
| August 1957 | Revised GOR formally issued |
| 23 August 1957(a) (FSD start) | NAA selected; design start authorized |
| October 1957 | P&W J52 engine selected |
| 16 October 1958(b) | Letter contract for first year's production |
| December 1958 | Ra[illegible]l program canceled |
| 23 April 1959(a) | First powered flight of a prototype Hound Dog |
| August 1959 | Fir[illegible] guidance flight |
| August 1959 | 150 hour test on engine completed |
| Late 1959 | First production autopilot used in flight test |
| 21 December 1959(a) | AF accepted first production missile, and delivered it to SAC that same month |
| September 1960 | Negotiations on production start |
| October 1960 | Nuclear Weapons System Safety Board judged system safe for alert status and peacetime flying |
| November 1960 | Production rate ordered reduced to 17/month because of continuing reliability and performance problems |
| January 1961 | Announcement that B-52s at W-P AFB would be equipped with missiles in mid-1961 |
| June 1961 | 215 missiles delivered by end of June, at rate of 18/month |
| June 1961 | First missile delivered to Air Training Command |
| September 1961 | Last of 247 GAM-77 missiles delivered |
| Late 1961 | Fully satisfactory flight tests obtained |
| 28 March 1963(a) | Production of the Hound Dog missile completed |

(a) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

SM-64 NAVAHO

| Date | Event |
|---|---|
| April 1946 | Navaho research and development program began as a one year study and research effort by North American Aviation |
| 1947 | Original program expanded to develop three missile designs with gradually increasing ranges |
| 26 May 1948(a) | First Navaho research test vehicle (NATIV) successfully launched at White Sands Proving Ground, New Mexico |
| Late 1949 | AF decided to develop the intermediate range vehicle with 1,000 nautical mile range into an air-launched weapon |
| February 1950 | Three phases outlined |
| July 1950 | AF had dropped plans for the air-launched missile in favor of supersonic, intercontinental guided missile |
| September 1950 | New program aimed at a surface-launched 5,500 mile missile by 1958 was proposed by North American and accepted by the AF |
| March 1952 | AF contracted for two XB-64 vehicles to be delivered in January and May 1954 |
| May 1952 | $4 million budget cut in FY1953 budget; schedule slippage pushes acceptance date to May 1954 |
| | XB-64A program delay also. Delivery of first missile rescheduled for June 1957 with first flight for December 1957 |
| October 1953 | AF decides to increase the size of the XB-64A rather than depend on super fuels to increase the range |
| Early 1955 | B symbol eliminated, replaced by SM |
| June 1955 | Formal mock-up inspection |
| 23 February 1956(a) | AF Secretary Donald A. Quarles directed the acceleration of the Navaho missile program |
| August 1956 | Three attempts made at static firing of the rocket booster for XSM-64, all unsuccessful |
| 6 November 1956 | First XSM-64 firing and flight was unseccessful; flight lasted only 26 seconds. |
| 22 March 1957 | Second launch of XSM-64 missile; considered a partial success |
| 25 April 1957 | Third attempt to launch XSM-64 failed |
| 12 July 1957(a) | Navaho program canceled |

(a) Strategic Air Command Chronology, 1939-1973, Office of the Historian, Hq Strategic Air Command, 2 September 1975.

TM-61A MATADOR

| Date | Event |
|---|---|
| 24 August 1945 | AAF military characteristics published for development of a ground-launched pilotless bomber with a 175-500 mile range and a 600 mph speed |
| Mid-December 1945 | Glenn L. Martin Co. submitted a development proposal |
| March 1946 | Letter contract for $864,000 for a one year research agenda awarded to Martin for a subsonic and supersonic 175-500 mile range guided missile |
| October 1946 | Further contract awarded Martin to continue research |
| December 1946 | Because of a reduction in AAF R&D funds, Martin was requested to continue research on subsonic missile only |
| 30 June 1947 | Materiel Command contracted for production of one missile |
| 10 December 1947 | First dummy missile launched |
| May 1948 | AF contracted for 14 experimental (XSSM-A-1) missiles |
| June 1948 | Contract signed |
| 19 January 1949 | First experimental missile launched |
| January 1949-December 1950 | 15 experimental missiles launched |
| September 1950 | AF gave Matador 1-A priority |
| September 1950 | First experimental missile delivered |
| 21 December 1950 | Letter contract calling for production line to be set up |
| 22 December 1950 | Second letter contract provided for 70 missiles |
| 7 December 1951 | First experimental Matador launched by military personnel |
| 24 March 1952 | New contract raised number of TM-61A missiles to 255 |
| June 1952 | First production Matador delivered |
| December 1952 | First successful flight of a TM-61A |
| November 1954 | Martin authorized to procure materials and begin necessary engineering work for the TM-61C production program |

# Appendix D

## TRENDS IN AIRCRAFT PRODUCTION UNIT COST

One possible explanation for the apparent decrease in typical production rates is that investment rates have not kept pace with the increase in unit cost of modern aircraft. To explore the relationship between unit cost and production rate, the unit cost of several aircraft was estimated on a constant-dollar basis.

Table D.1 documents the flyaway cost estimates for most aircraft models in the sample. Although the sample contains 36 types, the reasons reported in the note on the table caused ten deletions. In some cases data were not available for the exact aircraft model in the sample, so a similar aircraft (listed in column (2)) was used as a basis for the estimate.

Column (3) shows the flyaway cost estimates. Flyaway cost includes the following airborne and installed equipment: airframe, propulsion, electronics, armament, and other government furnished equipment. The estimates ignore RDT&E, operations, investment in peculiar support (i.e., peculiar aerospace ground equipment, training equipment, and technical data) and initial spares. Costs are shown as averages for the first 200 units in millions of fiscal year 1975 dollars.

The analysis adjusted costs for actual quantities to the first 200 units by means of assumed log-linear cumulative average learning curves. Manufacturing experience of the aerospace industry suggests an 80 percent slope for attack, fighter, and bomber aircraft and a 75 percent slope for patrol, cargo, and tanker aircraft. A Department of Defense procurement price index standardized costs to fiscal year 1975 dollars.[24] The date at which production for operational inventory began is shown in Col. (4), and the length of time required to produce the first two hundred items is in Col. (5). The average monthly production rate is shown in Col. (6). The last column (7) shows the average investment rate (in millions of FY 1975 dollars) implied by the production rate and the unit cost. That investment rate is then plotted for each aircraft in Fig. D.1 as a function of the date at which production began.

The data show considerable scatter and thus are subject to some different interpretations. The entire sample has so much scatter that a linear regression yields statistically insignificant results (i.e., no trend can be confidently identified). However, the two large strategic aircraft in the sample (B-47 and B-52) had exceptionally large investment rates, and if those are eliminated from the sample the average investment rate actually appears to be rising somewhat over the time period in question. This simply strengthens the argument that production rate is largely a resource-limited parameter and that the reduced production rates during recent years can be traced mainly to the increase in average unit cost.

[24]Department of the Air Force, *Department of Defense Deflators, USAF Cost and Planning Factors*, AFR 173-10, Vol. I (C6), Attachment 49, May 2, 1977.

Table D.1

FLYAWAY COST ESTIMATES FOR SELECTED AIRCRAFT[a]

| Model (1) | Proxy Aircraft (2) | Cumulative Average Flyaway Cost ($M FY 75) (3) | First Production Acceptance (4) | Time to Produce 200 a/c (5) | Units per Month (6) | Investment Rate ($M/mo.) (7) |
|---|---|---|---|---|---|---|
| Attack | | | | | | |
| A-3D-2 | A-3A/B (A-3D-1/2) | 5.8 | 1/55 | 65 | 3.1 | 18 |
| A-4D-1 | A-4A/B (A-4D-1/2) | 1.8 | 8/55 | 28 | 7.1 | 13 |
| A-6A | same | 10.5 | 4/62 | 58 | 3.5 | 37 |
| A-7A | A-7A/B/E | 5.0 | 3/66 | 22 | 9.1 | 45 |
| A-10A | same | 4.8 | 11/75 | 42 | 4.8 | 23 |
| Fighter | | | | | | |
| F-84B | same | 0.5 | 6/47 | 10 | 20.0 | 10 |
| F-86B | same | 1.6 | 5/48 | 17 | 11.8 | 19 |
| F-89C | same | 1.5 | 9/50 | 40 | 5.0 | 8 |
| F-4D | same | 5.2 | 5/55 | 27 | 7.4 | 38 |
| F-100A | same | 2.0 | 10/53 | 21 | 9.5 | 19 |
| F-101A | same | 3.8 | 5/57 | 12 | 16.7 | 63 |
| F-102A | same | 3.3 | 6/55 | 19 | 10.5 | 34 |
| F-104A | same | 2.7 | 1/57 | 23 | 8.7 | 23 |
| F-105D | same | 5.2 | 5/58 | 35 | 5.7 | 30 |
| F-106A | same | 8.7 | 6/58 | 22 | 9.1 | 79 |
| F-4H | F-4A/B | 7.7 | 12/60 | 22 | 9.1 | 70 |
| F-111A | same | 10.5 | 4/67 | 32 | 6.2 | 65 |
| F-14A | same | 20.5 | 5/72 | 50 | 4.0 | 82 |
| F-15A | same | 13.0 | 11/74 | 32 | 6.3 | 82 |
| F-16A | same | 8.5 | 8/78 | 29 | 6.9 | 59 |
| Bomber | | | | | | |
| B-47B | B-47E | 11.3 | 12/50 | 18 | 11.1 | 125 |
| B-52D | B-52 all models | 25.0 | 1/55 | 31 | 6.5 | 162 |
| Patrol | | | | | | |
| P-3A | P-3A/B/C | 12.0 | 3/62 | 57 | 3.5 | 42 |
| Cargo | | | | | | |
| C-130A | C-130A/B/D | 8.0 | 12/55 | 38 | 5.3 | 42 |
| C-141A | same | 11.5 | 10/64 | 30 | 6.7 | 77 |
| Tanker | | | | | | |
| KC-135A | same | 10.7 | 1/57 | 24 | 8.3 | 89 |

[a]Data unavailability, presence of preproduction estimates only, or manufacturing runs less than 200 units prevented calculations for the following aircraft: A-5A, F-3D-3, F-18A, F-94, B-58A, S-3A, C-5A, C-133A, B-70, and B-1.

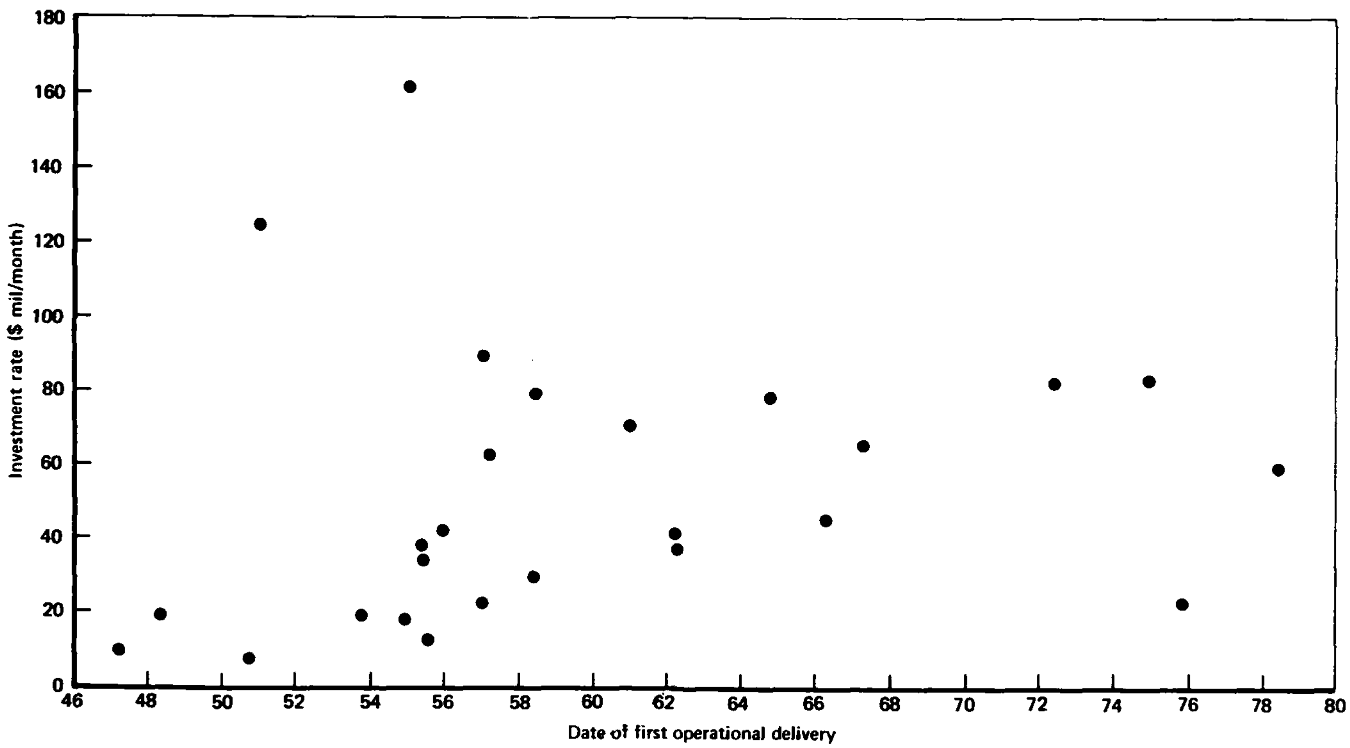


Fig. D.1—Aircraft production investment rate, average over first 200 units (constant-year dollars)